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ABSTRACT

This guide is intended to assist vocational educators in teaching an eight-unit module in shielded metal arc welding. The module is part of a welding curriculum that has been designed to be totally integrated with Missouri's Vocational Instruction Management System. The following topics are covered in the module: safety; theory, power sources, and electrodes; preparation, problems, and techniques; the technique of building pads of beads; methods of testing groove welds; pipe welding; plate welding fillets and grooves; and techniques for working with 16-gauge steel. The materials included in the module have been formatted for competency-based teaching and testing. All information sheets, transparency masters, job sheets, assignment sheets, and test items are keyed to specific competencies, and a cross-reference table has been included to aid in identifying the parts of the curriculum that relate to specific competencies. Unit tests to evaluate specific competencies have also been provided. (MN)

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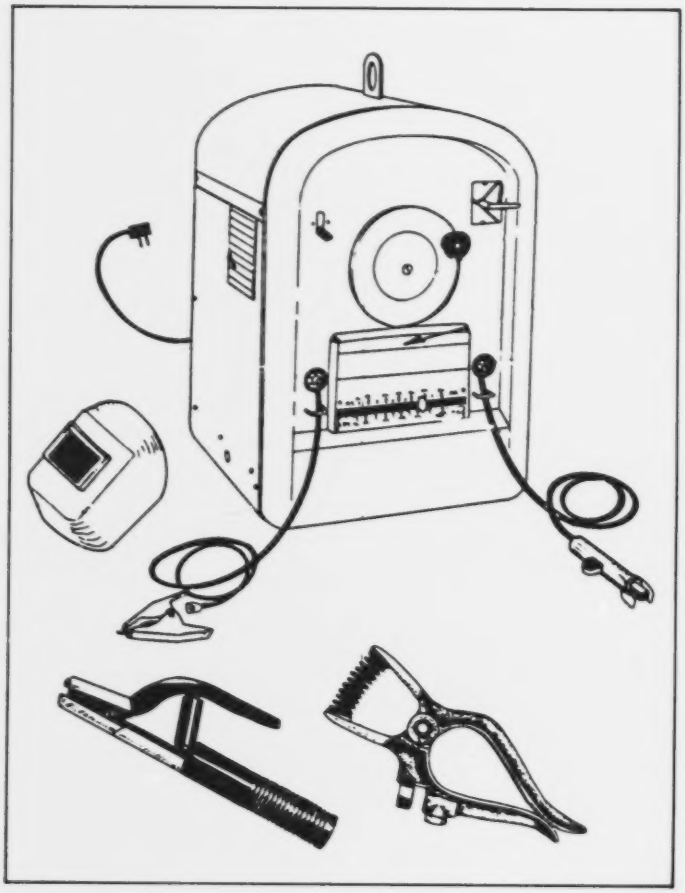
ELDING • Module 4

Shielded Metal Arc Welding (SMAW)



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Module: SMAW

Cross-Reference Table of Instructional Materials

Competency	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
E1	I 1.1-1.8			I 1.1		I 1-18	
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G1-3	VII 1.2c				VII 1.3		
G4-6	VII 1.2c				VII 1.4		
G7-10	VII 1.2d				VII 1.5		
H1-8	VIII 1.1a				VIII 1.1		
H9-16	VIII 1.1b				VIII 1.2		

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MODULE: SHIELDED METAL ARC WELDING

UNIT I: SAFETY

UNIT OBJECTIVES

Upon completion of this unit, the student should be able to discuss electrical safety in shielded metal arc welding (SMAW), handle welding cables properly, understand eye hazards, list safe clothing requirements and discuss environmental safety. This knowledge will be evidenced by achieving the specified score on the unit test.

SPECIFIC OBJECTIVES

1.1 Define SMAW safety terms.

1.2 Select true statements concerning electrical safety for arc welding.

1.3 Complete statements concerning important rules for handling welding cables or hollow containers.

1.4 Select true statements concerning hazards associated with arc rays.

1.5 Complete statements about types of welding hoods.

1.6 Determine steps in selecting a safe lens shade.

1.7 Complete statements concerning protective clothing required for arc welding.

1.8 Select true statements concerning environmental safety requirements.

MODULE: SHIELDED METAL ARC WELDING

UNIT I: SAFETY

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plan

1. Lesson 1: SAFETY

a. Information outline

b. Assignment sheet

AS 1.1: Solving problems concerning SMAW safety

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Giachino, Joseph and William Weeks. Welding Skills and Practices. Chicago: American Technical Publishers, Inc., 1976.

2. Horwitz, Henry. Welding Principles and Practices. Boston: Houghton Mifflin Company, 1979.

3. Sacks, J. Raymond. Welding Principles and Practices. Peoria, Ill.: Charles A. Bennett Co., Inc., 1976.

B. Curriculum guides

1. Fortney, Clarence, and Mike Gregory. Shielded Metal Arc Welding. Stillwater, Okla.: Mid-America Vocational Curriculum Consortium, Inc., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested approaches for teaching this unit

1. If other electrical welding processes have been presented before this unit, only a brief review may be necessary.

B. Suggested student activities

1. When students are in the arc welding area, quiz them over safety rules--safety cannot be emphasized too much.

C. Suggested supplemental audiovisual from The Media Center, State Fair Community College, Sedalia, Mo.

1. Shielded Metal Arc Welding Safety (W-76-102). 1976.

MODULE: SHIELDED METAL ARC WELDING

UNIT I: SAFETY

LESSON 1: SAFETY

I. Terms and definitions

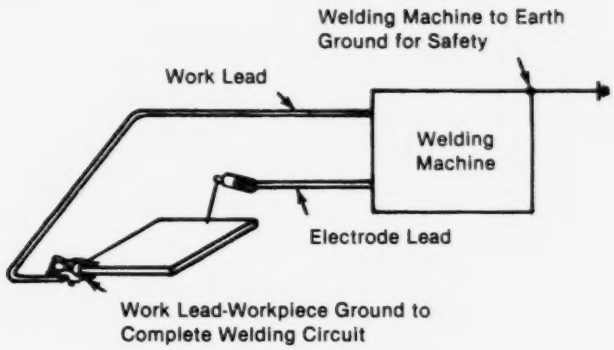
A. Oxygen displacement--a reduction of oxygen in the breathing zone around a welding activity caused by any arc or flame

B. Toxic hazard--poisonous gases, fumes and vapors produced by chemical reactions in certain welding processes

C. Contaminants--impurities formed from chemical reactions between base metals, flux and electrodes; usually present in fumes and vapors

II. Electrical safety for arc welding

A. All electrical equipment should have an earth ground for safety. This ground should not be confused with the work-lead-to-workpiece ground that completes the welding circuit.


Welding Machine to Earth Ground for Safety
Work Lead
Welding Machine
Electrode Lead
Work Lead-Workpiece Ground to Complete Welding Circuit

B. Keep electrical connections tight, clean and dry--poor connections can heat up, cause bad welds, produce dangerous arcs and sparking and even melting.

C. Keep work area, equipment and clothing dry because even a slight amount of moisture can conduct enough electricity to cause a severe shock.

D. Never dip an electrode holder into water to cool it.

E. When working with welding machines set up for multiple operations, be very careful not to touch hot parts of the electrode holders because open-circuit voltages from multiple machines are increased and can cause severe shock.

F. Remove electrode from electrode holder when work is finished.

G. Disconnect and lock out all electric power sources before doing any work on electrical equipment.

H. Keep welding cables as close to the work area as possible. Do not connect cables to building framework because current can be directed through lifting chains and cables, weakening them.

I. When working in high places, carefully examine work area for electrical hazards; a shock in such locations could cause a fall and severe injury.

J. Keep welding cables free of conduits, motors and any other equipment that could cause a short circuit.

K. Keep ground as close to the arc as possible.

III. Important rules for handling welding cables or hollow containers

A. Cables

1. Never drag cables through dirt or oil, and never pull on a cable to force it over an obstruction.

2. Use only clean, dry rags to clean welding cables. Never use gasoline or an oily rag for the job.

3. When not in use, keep welding cables coiled free of kinks and properly stored.

4. Never drape a welding cable over any type of gas cylinder; and <u>never</u> strike an arc on a gas cylinder.

B. Hollow castings or containers

1. Hollow castings or containers should be vented before any heating, cutting or welding activity.

2. Tanks, drums and containers should not be heated, cut or welded.

CAUTION: Some containers can be safely purged, but the rule for beginners is to never attempt such an activity.

IV. Hazards associated with arc rays

A. A welding arc produces ultraviolet and infrared radiation that can severely burn eyes that are unprotected with a proper shade of protective lens.

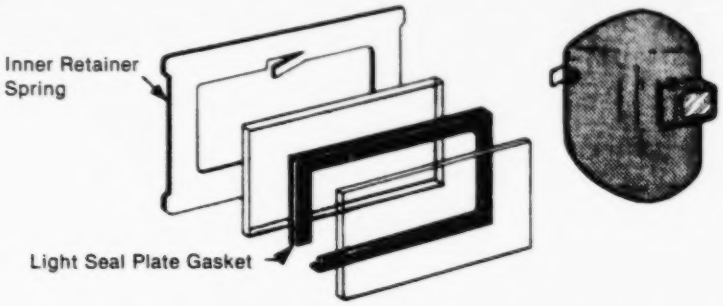
NOTE: While a welding hood or helmet protects the head from flying sparks, the shaded lens is also required for eye protection.

B. Radiation from a welding arc is strong enough to sunburn or sometimes blister bare skin if the exposure is intense or for an extended period. Arms, legs and torso should be covered with durable, flame-resistant clothing.

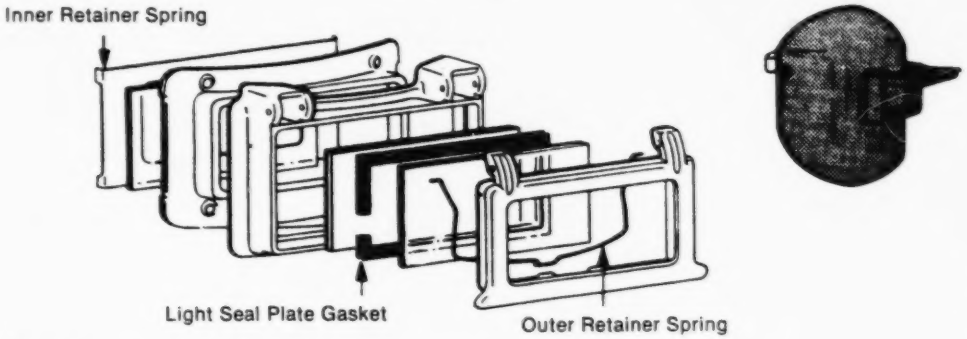
C. Work stations and work areas should be shielded to keep an arc flash from injuring nearby workers or visitors.

V. Types of welding hoods

A. Stationary filter lens: This type hood has a fixed lens housing with the shaded lens held in place by a spring retainer. From this a lens can be slipped out and replaced as welding requires.



B. Flip-front filter lens: This type of hood has a lens housing with a front side that can be flipped up, leaving a clear-glass lens that permits the hood to be worn while chipping.



VI. Steps in selecting a safe lens shade for SMAW

A. Determine electrode size and amperage range for the electrode.

NOTE: In oxy-acetylene welding and cutting, lens shade requirements are based on metal thickness, but in SMAW, lens shade requirements are based on electrode size and amperage range of the electrode.

B. Select lens shade according to the lens manufacturer's selection chart, but never select less than a #8 lens shade for SMAW.

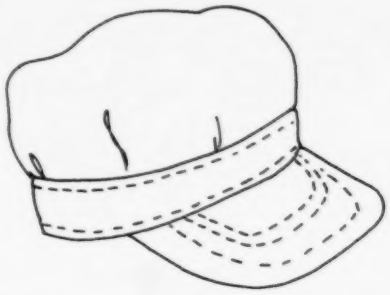
NOTE: If, when removing the hood after arc welding, you see white spots or white blotches as after-images, too much light is getting through the lens. Switch to a shade at least one number darker or check the seal on the lens.

Electrode size	Amperage	Shade #
---	30-75	8
1/16-5/32	75-200	10
3/16-1/4	200-400	12
5/16-3/8	400+	14

C. A general rule of thumb is that the larger the diameter of the electrode, the higher the number required for a lens shade.

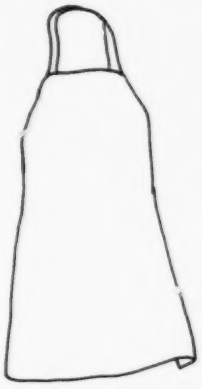
VII. Protective clothing required for arc welding

A. A welder's cap has a flexible bill and can be slipped around to cover either ear, keeping sparks or metal spatter out of the ear opening.



B. Do not wear clothing made from synthetic materials. Wear heavy, long-sleeved **shirts** with cuffless **pants** that are not frayed at the bottom. Shirt pockets should have flaps.

C. Leather jackets and aprons should be worn for additional protection, especially when welding out of position or in confined areas where flying sparks present an increased hazard.



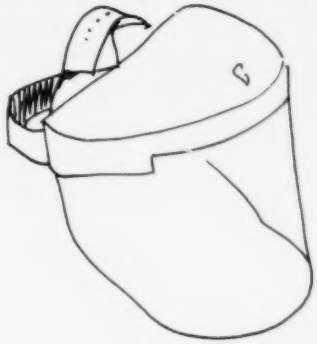
D. Boots should be made of heavy leather with uppers that reach above the ankle to help prevent burns from sparks and spatter. Although steel-toed boots are not required, they are highly recommended.

E. Heavy leather gloves with gauntlets are required for all welding and cutting activities.

F. Safety glasses should have nonmetal frames and impact-resistant lenses with side shields to protect from flying objects. Safety glasses should be worn at all times in the shop area.

NOTE: Safety glasses should meet both industry and Occupational Safety and Health Administration (OSHA) specifications.

G. Face shields should be a clear plastic to provide good visibility when chipping or grinding, but still provide protection from particles of slag or metal.



VIII. Environmental safety requirements

A. Ventilation

1. Many welding activities produce toxic fumes and vapors that are hazardous to breathe.

2. Every work station should be equipped with ventilation or an exhaust system capable of safely removing dangerous and irritating smoke and contaminants.

CAUTION: Always position your head to the side of rising fumes.

B. Respirators

1. In confined areas when the hazard of toxic fumes is increased, a welder should wear an air-supplied respirator or a self-contained breathing apparatus.

2. A filter-type mask cannot compensate for oxygen displacement and is not adequate in these situations.

C. Noise

1. This is a work place hazard frequently overlooked.

2. Ear plugs or muffler-type ear protectors should be worn when the work area subjects a welder to high noise levels, especially high noise levels that are continuous.

D. Lighting

1. Lighting in a work area or at a work station should be bright enough to provide good, glare-free visibility.

2. Poorly lit work areas contribute to eye fatigue, irritation and poor work.

E. Work area

1. Make sure the work area is clear of water or damp areas. If the area is wet, dry it before welding. If drying is not possible, welders must find something to insulate or separate themselves from the water. A wooden platform or pallet will work if the welder-to-platform area is dry and non-metallic.

CAUTION: Don't stand in--or in any way be in contact with--water when welding. You could be shocked or electrocuted.

2. Since current travels through the cables from the welding machines to the welding area and back to the machines on another cable, it is possible for the person welding to become a better conductor than the cable.

SOLVE PROBLEMS CONCERNING SMAW SAFETY

Read the following statements carefully. Write a brief statement that recommends a specific solution if there is a safety violation presented.

1. A fellow student is attempting to replace a tension spring in an electrode clamp while the welding machine is still turned on. Is there a problem? ____

   Solution: _____

   _____

   _____

2. A fellow student is attempting to clean a welding cable with an oily rag. Is there a problem? ____

   Solution: _____

   _____

   _____

3. A fellow student is arc welding in an unshielded area that has several other students nearby. Is there a problem? ____

   Solution: _____

   _____

   _____

4. A fellow student complains that she can't see to arc weld at 50 amps through a #8 lens shade, so she puts on a #4 lens shade in her welding hood and starts to weld. Is there a problem? ____

   Solution: _____

   _____

   _____

5. A fellow student is arc welding in such a position that there is danger that spatter and sparks will strike the left side of his face which is uncovered. Is there a problem? ____

   Solution: _____

   _____

   _____

INSTRUCTOR'S NOTE: Completion of this assignment sheet to specified score is the student's partial evaluation for competency E1.

ANSWERS TO AS 1.1

NOTE: Student answers should approximate those given below.

1. Yes. The welding machine should be disconnected from the power source.
2. Yes. Only a dry rag should be used to clean a welding cable.
3. Yes. Erect a shielding curtain or panel around the work area.
4. Yes. Use a minimum #8 lens shade and take a position that will provide better visibility.
5. Yes. A welding cap pulled down over the left ear would eliminate the hazard.

MODULE: SHIELDED METAL ARC WELDING

UNIT I: SAFETY

UNIT TEST

Match the terms on the right with appropriate definitions.

____ 1.	A reduction of oxygen in the zone around a welding activity caused by any arc or flame	a.	Contaminants
____ 2.	Poisonous gases, fumes and vapors produced by chemical displacement reactions in certain welding processes	b.	Filter-type mask
____ 3.	Impurities formed from chemical reactions between base metals, flux and electrodes, usually present in fumes and vapors	c.	Noise
____ 4.	Equipment necessary for safe breathing where toxic fumes are a hazard	d.	Oxygen displacement
____ 5.	The most commonly overlooked welding work place hazard	e.	Self-contained breathing apparatus
		ab.	Toxic hazards
		ac.	Ventilation

Choose the letter of the option which best answers the question or completes the statement.

____ 6. For safety reasons, all electrical equipment should have ____ .

a. An earth ground
b. A work-lead-to-workpiece ground
c. Ground connected to machine case
d. None of the above

____ 7. Which of the following is <u>not</u> a proper electrical safety guideline?

a. Keep electrical connections tight, clean and dry.
b. Keep work area, equipment and clothing dry.
c. Dip electrode in water to cool it only in emergencies.
d. When working with welding machines set up for multiple operation, be very careful not to touch hot parts of electrode holder.

____ 8. Which is an approved method of handling cables and hoses?

a. A cable can be pulled over an obstruction.
b. Use gas or an oil rag to clean cables and hoses.
c. When <u>not</u> in use, cables and hoses can be coiled with some kinks in them.
d. Never drag cables or hoses through dirt or oil.

___ 9. Never drape a welding cable over any _____ ; never strike an arc on a ____ ____ .

a. Sharp piece of metal, non-metallic surface
b. Part of the body, gas cylinder
c. Gas cylinder, gas cylinder
d. Gas cylinder, non-metallic surface

___ 10. Hollow castings, tanks, drums and sealed containers should be _____ before any heating, cutting or welding activity.

a. Filled with water
b. Purged with flammable gas
c. Purged with inert gas
d. None of the above

___ 11. Which is <u>not</u> an arc ray hazard?

a. Ultraviolet light
b. Eye burn
c. Arc flash
d. Sunburn or blistering
e. None of the above

___ 12. The _____ type of welding hood has a _____ lens housing with the shaded lens held in by a spring retainer.

a. Stationary filter lens, flexible
b. Flip-front lens, flexible
c. Flip-front lens, fixed
d. Stationary filter lens, fixed

___ 13. When choosing an electrode, what should be determined first?

a. Electrode amperage range only
b. Electrode size only
c. Electrode size and amperage range
d. None of the above

___ 14. Select lens shade according to the lens manufacturer's selection chart, but never select less than a _____ lens shade for SMAW.

a. #5
b. #7
c. #8
d. #11

___ 15. A general rule of thumb is that the _____ the diameter of the electrode, the __ _____ the number required for a lens shade.

a. Smaller, higher
b. Larger, higher
c. Larger, smaller
d. None of the above

___ 16. Which of the following does not describe proper SMAW protective clothing?

a. Boots should be made of heavy leather. Steel-toed boots are not recommended because they are too heavy and cause fatigue.
b. A welder's cap has a flexible bill that can be slipped around to cover either ear and keep sparks or metal spatter out of the ear opening.
c. Leather jackets and aprons should be worn for additional protection.
d. Heavy leather gloves with gauntlets are required for all welding and cutting activities.

___ 17. Which of the following does not describe proper SMAW protective clothing?

a. Wear heavy, long-sleeved shirts with pockets that have flaps and cuffless pants that are not frayed at the bottom.
b. Safety glasses should have nonmetal frames and impact-resistant lenses with side shields to protect from flying objects. They should be worn only when preparing metal for welding.
c. Face shields should be a clear-plastic type to provide good visibility when grinding or sanding base metals.
d. Heavy leather gloves with gauntlets are required for all welding and cutting activities.

___ 18. Which type of work place hazard is most frequently overlooked?

a. Ventilation
b. Lighting
c. Noise
d. None of the above

NOTE: Completion of this unit test to a specified score is the student's final evaluation for competency E1: Demonstrate safety procedures.

ANSWERS TO UNIT TEST (E1)

1. d
2. ab
3. a
4. e
5. c
6. a
7. c
8. d
9. c
10. c
11. e
12. d
13. c
14. c
15. b
16. a
17. b
18. c

MODULE: SHIELDED METAL ARC WELDING

UNIT II: THEORY, POWER SOURCES AND ELECTRODES

UNIT OBJECTIVES

Upon completion of this unit, the student should be able to define terms related to SMAW equipment, applications and techniques; know electrical and performance characteristics of various welding machines; understand the purpose of SMAW accessories; and understand AWS electrode classifications for mild steel and alloy electrodes. This knowledge will be evidenced by achieving the specified score on the unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student will be able to:

1.1 Match terms and definitions related to SMAW equipment, applications and techniques.

1.2 Match welding machines with electrical characteristics.

1.3 Match basic elements of arc welding with their importance.

2.1 Match types of welding machines with performance characteristics.

2.2 Complete statements concerning basic SMAW accessories and purposes.

2.3 Identify parts of an arc welder.

3.1 Solve problems concerning AWS electrode classifications for mild steel and alloy electrodes.

MODULE: SHIELDED METAL ARC WELDING

UNIT II: THEORY, POWER SOURCES AND ELECTRODES

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: SMAW THEORY

   a. Information outline

2. Lesson 2: POWER SOURCES AND CURRENT

   a. Information outline

3. Lesson 3: ELECTRODE SELECTION

   a. Information outline

   b. Transparency master

      TM 3.1: Electrode sizing

   c. Handouts

      HO 3.1: Mild steel electrode groups
      HO 3.2: Selection data for mild steel electrodes

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Giachino, Joseph and William Weeks. Welding Skills and Practices. Chicago: American Technical Publishers, Inc., 1976.

2. Sacks, J. Raymond. Welding Principles and Practices. Peoria, Ill.: Charles A. Bennett Co., Inc., 1976.

B. Curriculum guides

1. Fortney, Clarence, and Mike Gregory. Shielded Metal Arc Welding. Stillwater, Okla.: Mid-America Vocational Curriculum Consortium, Inc., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Be sure students review the material in this unit carefully; there are important areas that a welder will need to refer to in the future.

2. Explain the importance of theory, power source and electrode selection through self-experience and related situations. Invite a local welding supplier to emphasize the importance of this knowledge.

B. Suggested student activities

1. Supervise student performance of preventative maintenance such as cleaning out welders, greasing bearings and checking cables, connections and terminals.

C. Suggested supplemental materials from The Media Center, State Fair Community College, Sedalia, Mo.

1. Setting Up and Operating the Metal Arc Welding Machine (W-77-105. 1977.

2. Basic Weave Patterns and Padding (W-77-108). 1977.

3. Metal Arc Welding in the Horizontal Position (W-79-112). 1979.

4. Vertical Position Shielded Arc Welding (W-78-113). 1978.

5. Overhead Position Metal Arc Welding (W-79-114). 1979.

MODULE: SHIELDED METAL ARC WELDING

UNIT II: THEORY, POWER SOURCES AND ELECTRODES

LESSON 1: THEORY OF SHIELDED METAL ARC WELDING

I. Terms and definitions

A. Weld axis--a line through the length of a weld, perpendicular to the cross-section at its center of gravity

B. Root pass--first bead welded in or on a joint

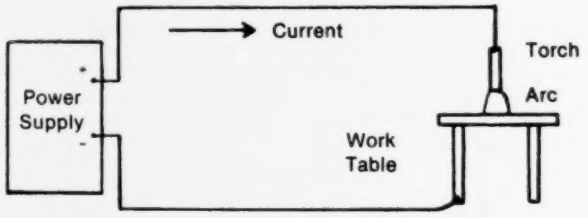
C. Hot pass--second bead welded over the root pass

D. Filler pass--remainder of beads required to complete the joint from hot pass out to cap pass

E. Cap pass--final pass or passes needed to complete a welded joint

II. Welding machines and electrical characteristics

A. Basic circuit--complete loop current must travel from the power supply to the arc and back to the power supply

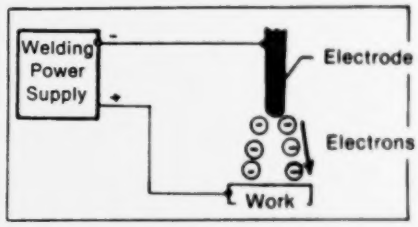


B. Polarity--direction current flows through a basic welding circuit; expressed as straight or reverse in relation to an AC or DC current

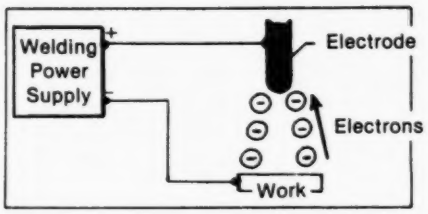
C. AC (alternating current)--current that alternates from one direction to another 60 times per second (expressed as 60 Hertz)

D. DC (direct current)--current that flows in only one direction

E. DCSP (direct current, straight polarity)--produced by a negative electrode and a positive workpiece that causes the current to flow from the electrode to the workpiece



F. DCRP (direct current, reverse polarity)--produced by a positive electrode and a negative workpiece that causes the current to flow from the workpiece to the electrode.



III. Basic elements of arc welding

A. Electrode selection must be related to both the type and thickness of a base metal. One rule of thumb is that electrode diameter should not exceed the thickness of the base metal.

B. Welding speed is the greatest factor in reducing welding costs. One rule of thumb is to use the largest allowable electrode at the highest acceptable amperage.

C. Welding position

1. For vertical, overhead and horizontal butt welds, the maximum size for an E6010 or E6011 is 3/16".

2. For these same positions with a low-hydrogen electrode, the maximum size is 5/32".

D. With joint preparation, remember that a narrow V-groove in a butt joint usually prevents use of a large electrode on the first pass.

E. In fit-up, backup strips are permitted with certain codes.

F. Machine capacity: Amperage ratings on some welding machines may not be large enough to handle large electrodes properly.

G. Amps

1. Settings are always determined by electrode selection and welding position.

2. Turn down amps when welding vertical up; turn up amps when welding vertical down.

H. Volts

1. On some SMAW machines, the VV (variable voltage) from 17-45 volts can be adjusted at the machine.

2. Keep in mind that a long arc increases voltage and a short arc decreases voltage.

I. Polarity is determined by electrode selection. Correct polarity is a MUST in all electric arc welding processes.

MODULE: SHIELDED METAL ARC WELDING

UNIT II: THEORY, POWER SOURCES AND ELECTRODES

LESSON 2: POWER SOURCES

I. Types and characteristics of welding machines

A. AC transformer--changes high-voltage, low-amperage AC in machines that usually have a 230-volt, single-phase input current

B. DC transformer-rectifier welder--changes AC to DC from either single-phase or three-phase power to produce either CV (constant voltage) or VV (variable voltage)

C. AC or DC transformer-rectifier--changes high-voltage, low-amperage AC to low-voltage, high-amperage AC or DC; ideal for adjustment to different materials and welding positions

D. DC generator (motor or engine)

1. Current varies with the speed the armature turns.

2. Polarity changes are made by flipping a switch or reversing weld lead connections.

3. Generator can be powered with an AC motor or a gas or diesel engine.

II. Basic SMAW accessories and purposes

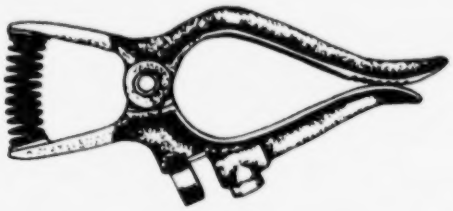
A. Cables--insulated copper, extra-flexible leads that carry the current from the power source to the electrodes. They vary in size or diameter according to machine capacity and length requirements.

Recommended copper welding cable sizes

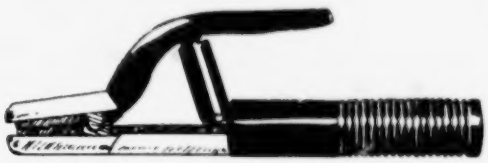
Power source		Avg. cable size for combined length of electrode and ground cables				
Size in amperes	Duty cycle, %	0-15m (0-50')	15-30m (50-100')	30-46m (100-150')	46-61m (150-200')	61-76m (200-250')
100	20	6	4	3	2	1
180	20-30	4	4	3	2	1
200	60	2	2	2	1	1/0
200	50	3	3	2	1	1/0
250	30	3	3	2	1	1/0
300	60	1/0	1/0	1/0	2/0	3/0
400	60	2/0	2/0	2/0	3/0	4/0
500	60	2/0	2/0	3/0	3/0	4/0
600	60	2/0	2/0	3/0	4/0	*

*Use two 3/0 cables in parallel

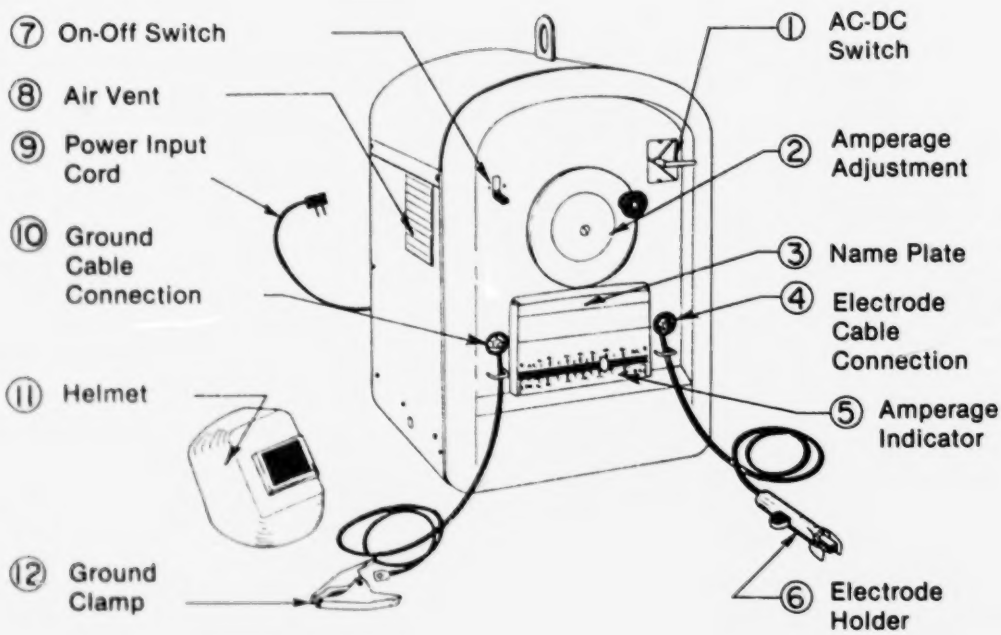
B. Clamps--used to fasten cables to workpiece or table where the workpiece is positioned so the welding circuit will be completed. Some operate with spring pressure, while others are magnetic.



C. Electrode holders--hand-held clamping devices that hold the electrode during welding. They should be selected according to machine's maximum output rating. These holders should be well insulated, lightweight and sturdy enough to stand up under heavy use.



III. Parts of an arc welding machine



MODULE: SHIELDED METAL ARC WELDING

UNIT II: THEORY, POWER SOURCES AND ELECTRODES

LESSON 3: ELECTRODE SELECTION

I. AWS electrode classifications for mild steel and alloy electrodes (HO 3.1)

A. The prefix "E" designates arc-welding electrode.

B. The first two digits of four-digit numbers and the first three digits of five-digit numbers indicate minimum tensile strength.

Example:

E60XX	60,000-psi tensile strength
E70XX	70,000-psi tensile strength
E110XX	110,000-psi tensile strength

C. The next-to-last digit indicates position.

Example:

EXX1X	All positions
EXX2X	Flat positions and horizontal fillets
EXX3X	Flat positions only

D. The last two digits together indicate the type of covering and the current to be used.

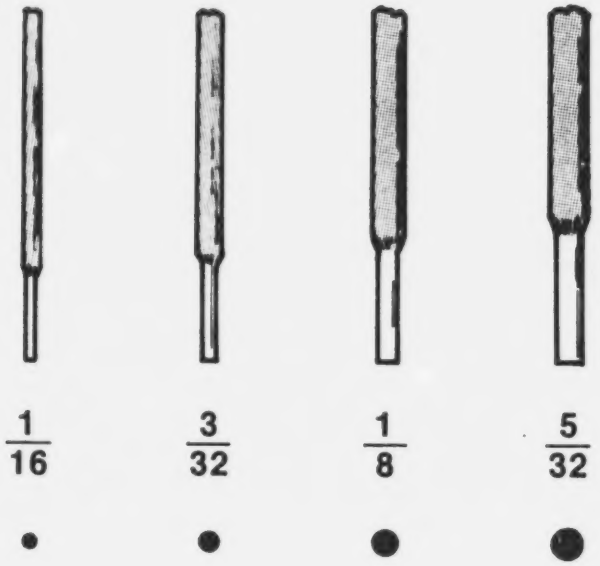
Fourth digit	Type of coating	Welding current
0	Cellulose sodium	DCEP
1	Cellulose potassium	AC or DCEP
2	Titania sodium	AC or DCEN
3	Titania potassium	AC or DCEN or DCEP
4	Iron powder titania	AC or DCEN or DCEP
5	Low hydrogen sodium	DCEP
6	Low hydrogen potassium	AC or DCEP
7	Iron powder iron oxide	AC or DCEN
8	Low hydrogen potassium iron powder	AC or DCEP
E6020	Iron oxide sodium	AC or DCEN or DCEP
E6022	High iron oxide	AC or DCEN or DCEP
E7048	Low hydrogen potassium iron powder	AC or DCEP

E. The last digit indicates coating type and welding polarity.

F. Mild steel electrodes are also grouped according to characteristics such as fast-freeze, fill-freeze, fast-fill and low hydrogen.

G. In addition to the AWS classification system, electrodes are also classified according to the diameter size of the wire in the flux. (TM 3.1)

ELECTRODE SIZES



MILD STEEL ELECTRODE GROUPS

AWS#	Group	Characteristics	Applications
E6010 E6011	Fast-freeze	Produce a deep, penetration arc that leaves a fast-freezing flat bead with little slag	All types of welding in all positions; almost always used with reverse polarity, although some can be used with AC
E6012 E6013 E7014	Fill-freeze	Produce a moderate arc and leave beads with distinct, even ripples with complete slag coverage	Can be used in all positions but preferred for overhead and vertical welding; commonly straight polarity electrodes, although sometimes used with AC
E6027 E7024	Fast-fill	Heavily coated with iron powder to produce a soft arc that provides a fast deposit rate and leaves a smooth bead with heavy slag	Frequently used in production welding where work can be positioned for downhand welding
E7018 E7028	Low hydrogen	Little hydrogen in coating but must be used soon after opening or stored in a drying oven to avoid moisture	Can be used in all positions; first choice for welding problem steels because of outstanding crack-resistance and elimination of porosity

SELECTION DATA FOR MILD STEEL ELECTRODES

AWS CLASS	ELECTRODE POLARITY (+) = "REVERSE" (−) = "STRAIGHT"	SIZES AND CURRENT RANGES (Amps.)							
		5/64" SIZE	3/32" SIZE	1/8" SIZE	5/32" SIZE	3/16" SIZE	7/32" SIZE	1/4" SIZE	5/16" SIZE
MILD STEEL									
E6010	DC(+)		40-75	75-130	90-175	140-225	200-275	220-325	240-400
E6012	DC(−)			80-135	110-180	155-250	225-295	245-325	
	AC			90-150	120-200	170-275	250-325	275-360	
E6011	AC		50-85	75-120	90-160	120-200	150-260	190-300	
	DC(+)		40-75	70-110	80-145	110-180	135-235	170-270	
E6011	AC			80-130	120-160				
	DC(±)			70-120	110-150				
E6013	AC	50-80	75-105	110-150	160-200	205-260			
	DC(±)	45-75	70-95	100-135	145-180	190-235			
E7014	AC			110-160	150-225	200-260	260-340	280-425	
	DC(−)			100-145	135-200	180-235	235-305	260-380	
E6013	AC			100-150	150-200	200-260			
	DC(±)			90-135	135-180	180-235			
E6011	AC		40-90	60-120	115-150				
	DC(+)		40-80	55-110	105-135				
E7024	AC		65-102	115-175	180-240	240-300	300-380	340-440	
	DC(±)		60-110	100-160	160-215	220-280	270-340	320-400	
E6027	AC				190-240	250-300	300-380	350-450	
	DC(±)				175-215	230-270	270-340	315-405	
E7024	AC			115-175	180-240	240-315	300-380	350-450	380-600
	DC(±)			100-160	160-215	215-285	270-340	315-405	360-600
E7018	DC(+)		70-100	90-150	120-190	170-280	210-330	290-430	375-500
	AC		80-120	110-170	135-225	200-300	260-380	325-440	400-530
E7018-1	DC(+)		70-110	95-160	120-190	180-270	250-330	300-400	
	AC		80-110	100-170	135-225	210-290	270-370	325-420	
7018 (white numbers)	DC(+)		85-110	110-160	130-200	180-270	250-330	300-400	
	AC			120-170	140-230	210-290	270-370	325-420	
E7028	AC				180-270	240-330	275-410	360-520	
	DC(+)				170-240	210-300	260-380		

MODULE: SHIELDED METAL ARC WELDING

UNIT II: THEORY, POWER SOURCES AND ELECTRODES

UNIT TEST

Match terms on the right with definitions.

____ 1.	Line through the length of a weld which is perpendicular to the cross-section at its center of gravity	a.	AC
____ 2.	First bead welded in or on a joint	b.	AC or DC transformer-rectifier
____ 3.	Second bead welded over the root pass	c.	AC transformer
____ 4.	Remaining beads required to complete joint from hot pass to cap pass	d.	Basic circuits
____ 5.	Final pass or passes needed to complete a welded joint	e.	Cap pass
____ 6.	Current must travel in a complete loop from the power supply to the arc and back.	ab.	DC
____ 7.	Direction current flows through a welding circuit; expressed as straight or reverse in relation to current	ac.	DC generator
____ 8.	Current that alternates from one direction to another 60 times per second; expressed as 60 Hertz	ad.	DC transformer-rectifier welder
____ 9.	Current that flows in only one direction	ae.	DCRP
____ 10.	Produced by negative electrode and positive workpiece where current flows from electrode to workpiece	bc.	DCSP
____ 11.	Produced by positive electrode and negative workpiece where current flows from workpiece to electrode	bd.	Filler pass
____ 12.	Changes high-voltage, low-amperage AC to low-voltage, high-amperage AC in machines that usually are 230-volt, single-phase input current	be.	Hot pass
____ 13.	Changes AC to DC from either single-phase or three-phase power to produce either CV or VV	cd.	Polarity
____ 14.	Changes high-voltage, low-amperage AC to low-voltage, high-amperage AC or DC; ideal for adjustment to different materials and welding positions	ce.	Root pass
____ 15.	Current varies with the speed the armature turns; powered with an AC motor or gas or diesel engine	de.	Weld axis

Choose the option which best answers the question or completes the statement.

____ 16. Cables are insulated _____ , extra-flexible leads that carry the current from the power source to the electrode. They vary in size or diameter according to _____ capacity and length requirements.

a. Copper, machine
b. Steel, job
c. Aluminum, job
d. Aluminum, machine

____ 17. Why are clamps used to fasten cables to the workpiece or table where the workpiece is positioned?

a. To free operator's hands for equipment operation
b. For a positive earth ground
c. To reduce chance of operator electrocution
d. So the welding circuit will be completed

____ 18. Electrode holders should be _____ .

a. Water cooled
b. Gas cooled
c. Selected according to machine's minimum output rating
d. Well insulated, lightweight and sturdy enough to stand up under continued use

____ 19. An electrode with the capability of running in all four basic welding positions will have _____ as the second number in a four-digit system.

a. 3
b. 1
c. 2
d. None of the above

____ 20. The "E" prefix on E70XX represents _____ .

a. Electrode
b. Excellent
c. Extra strength
d. None of the above

____ 21. Two fast-freeze electrodes are _____ .

a. 7014 and 7018
b. 6010 and 7018
c. 6010 and 6011
d. None of the above

____ 22. The last (fourth) digit in the four-digit electrode numbering system tells _____ .

a. Tensile strength
b. The coating type on electrode
c. The position electrode can be run in
d. Amperage requirements for that electrode

____ 23. An 11018 electrode will have how much tensile strength?

a. 110 lbs.
b. 1,101 lbs.
c. 11,018 lbs.
d. 110,000 lbs.

Match basic elements of arc welding with their importance. (Each element is used only once.)

____ 24. Must be related to both the type and thickness of a base metal; diameter should not exceed base metal thickness

____ 25. The greatest factor in reducing welding costs

____ 26. For vertical, overhead and horizontal butt welds. The maximum size for an E6010 or E6011 is 3/16", and for these same positions with a low-hydrogen electrode, the maximum size is 5/32".

____ 27. A narrow V-groove in a butt joint will usually prevent the use of a large electrode on the first pass.

____ 28. Back-up strips are permitted with certain codes.

____ 29. Amperage ratings on some welding machines may not be large enough to handle large electrodes properly.

____ 30. Settings are always determined by electrode selection and welding position. Turn down when welding vertical up and turn up when welding vertical down.

____ 31. One rule of thumb is that a long arc increases this and a short arc decreases this.

____ 32. Determined by electrode selection; having this correct is a must in all electric arc welding processes

a. Amps
b. Electrode selection
c. Fit-up
d. Joint preparation
e. Machine capacity
ab. Polarity
ac. Volts
ad. Welding position
ae. Welding speed

Identify the parts on the arc welder illustrated below.

___ 33.

___ 34.

___ 35.

___ 36.

___ 37.

___ 38.

___ 39.

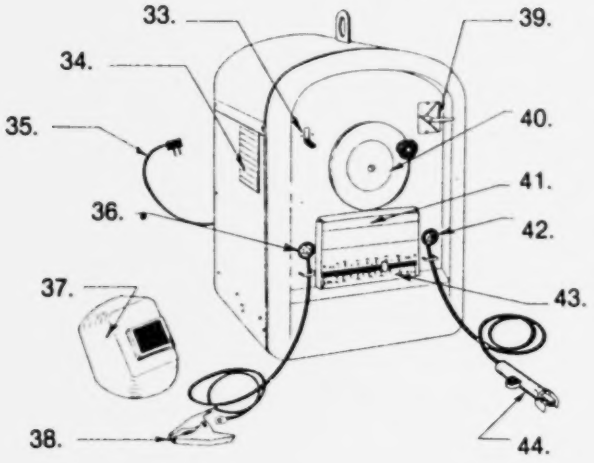
___ 40.

___ 41.

___ 42.

___ 43.

___ 44.



a. AC-DC switch

b. Air vent

c. Amperage indicator

d. Amperage adjustment

e. Electrode holder

ab. Electrode cable connection

ac. Ground clamp

ad. Ground cable connection

ae. Helmet

bc. Nameplate

bd. On-off switch

be. Power input cord

ANSWERS TO UNIT TEST

1.	de	(E2)
2.	ce	(E2)
3.	be	(E2)
4.	bd	(E2)
5.	e	(E2)
6.	d	(E2)
7.	cd	(E2)
8.	a	(E2)
9.	ab	(E2)
10.	bc	(E2)
11.	ae	(E2)
12.	c	(A14)
13.	ad	(A14)
14.	b	(A14)
15.	ac	(A14)
16.	a	(E3)
17.	d	(E3)
18.	d	(E3)
19.	d	(E4)
20.	a	(E4)
21.	c	(E4)
22.	b	(E4)
23.	d	(E4)
24.	b	(E4)
25.	ae	(E2)
26.	ad	(E2)
27.	d	(E2)
28.	c	(E2)
29.	e	(E2)
30.	a	(E2)
31.	ac	(E2)
32.	ab	(E2)
33.	bd	(E3)
34.	b	(E3)
35.	be	(E3)
36.	ad	(E3)
37.	ae	(E3)
38.	ac	(E3)
39.	a	(E3)
40.	d	(E3)
41.	bc	(E3)
42.	ab	(E3)
43.	c	(E3)
44.	e	(E3)

MODULE: SHIELDED METAL ARC WELDING

UNIT III: PREPARATION, PROBLEMS AND TECHNIQUES

UNIT OBJECTIVES

Upon completion of this unit, the student should be able to identify various joints, common joint preparation steps, characteristics of good and bad welds, poor weld causes, electrode angles and meanings, and basic SMAW techniques. The student should demonstrate striking and restarting an arc and should crater and backfill on mild steel plate. This knowledge will be evidenced by achieving the specified score on the unit test and job sheet.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student will be able to:

1.1 Identify lap, T, butt, edge and corner joints.

1.2 Identify the two common steps in joint preparation: beveling and grinding.

2.1 Match characteristics of good and bad welds with causes.

2.2 Identify solutions to poor weld problems.

3.1 Match electrode angles to meanings.

3.2 Explain basic SMAW techniques.

3.3 Determine proper uses for various bead running techniques.

3.4 Demonstrate the ability to:

a. Strike and restart an arc; crater and backfill at edge of plate.

MODULE: SHIELDED METAL ARC WELDING

UNIT III: PREPARATION, PROBLEMS AND TECHNIQUES

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: PREPARATION OF METAL FOR WELD PROCEDURE

   a. Information outline

   b. Transparency master

      TM 1.1: Typical welded joints

2. Lesson 2: CAUSES AND CURES OF WELDING PROBLEMS

   a. Information outline

   b. Transparency master

      TM 2.1: Good and bad welds

3. Lesson 3: ELECTRODE ANGLES AND SMAW TECHNIQUES

   a. Information outline

   b. Transparency master

      TM 3.1: Basic motions for electrode manipulation

   c. Job sheet

      JS 3.1: Strike and restart arc; crater and backfill at edge of plate

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Giachino, Joseph and William Weeks. Welding Skills and Practices. Chicago: American Technical Publishers, Inc., 1976.

2. Sacks, J. Raymond. Welding Principles and Practices. Peoria, Ill.: Charles A. Bennett Co., Inc., 1976.

B. Curriculum guide

1. Fortney, Clarence, and Mike Gregory. Shielded Metal Arc Welding. Stillwater, Okla.: Mid-America Vocational Curriculum Consortium, Inc., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Explain (or ask an industry representative to explain) the importance of material preparation, welding problems and cures, and proper welding techniques.

2. Give repeated demos to ensure that students comprehend this vital area of SMAW.

3. Give plenty of practice time in restarting and ending welds.

B. Suggested supplemental materials from The Media Center, State Fair Community College, Sedalia, Mo.

1. Setting Up and Operating the Metal Arc Welding Machine (W-77-105). 1977.

2. Basic Weave Patterns and Padding (W-77-108). 1977.

3. Metal Arc Welding in the Horizontal Position (W-79-112). 1979.

4. Vertical Position Shielded Arc Welding (W-78-113). 1978.

5. Overhead Position Metal Arc Welding (W-79-114). 1979.

MODULE: SHIELDED METAL ARC WELDING

UNIT III: PREPARATION, PROBLEMS AND TECHNIQUES

LESSON 1: PREPARATION OF METAL FOR WELD PROCEDURE

I. Typical welded joints (TM 1.1)

A. Lap

B. T

C. Butt

D. Edge

E. Corner

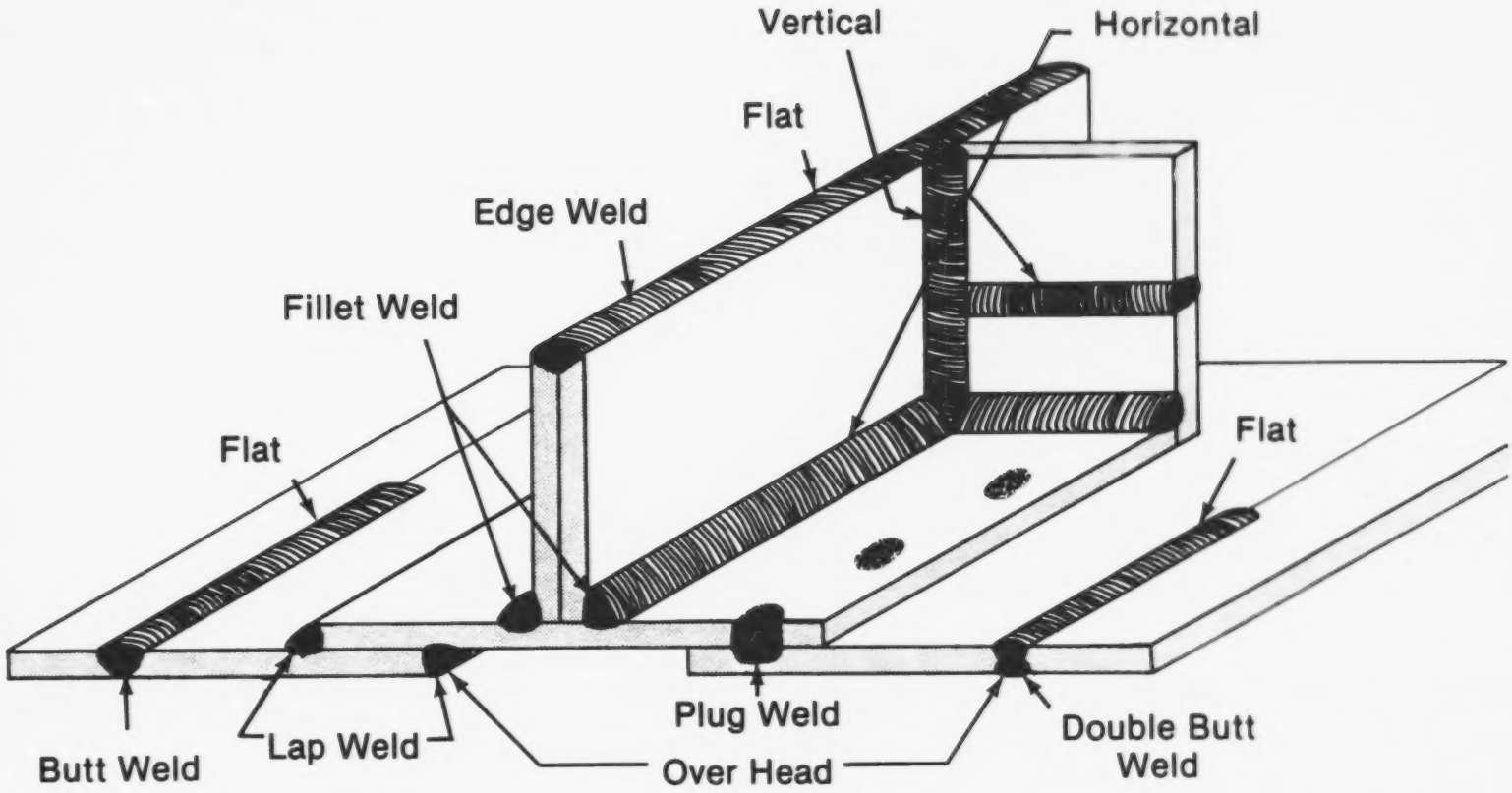
II. Basic steps in joint preparation

A. Beveling: Putting angles on pieces of material so that the weld will have good penetration below the surface of the base metal when joined.

NOTE: Bevels may be machined or cut with a saw, but the most common method is to use an oxy-acetylene cutting torch.

B. Grinding: An abrasive device, usually a portable grinder, removes slag metal from the weld area.

NOTE: Although grinding can be used to bevel plates, it is mostly used to clean slag off a weld area after cutting or welding and for grinding and feathering edges for tie-ins.



TYPICAL WELDED JOINTS

TM 1.1

SMAW 49

MODULE: SHIELDED METAL ARC WELDING

UNIT III: PREPARATION, PROBLEMS AND TECHNIQUES

LESSON 2: WELDING PROBLEMS, CAUSES AND CURES

I. Causes and characteristics of good and bad welds (TM 2.1)

A. Normal current, voltage and speed: smooth, well-formed bead with no undercutting, overlapping or piling of slag

B. Low current: poor penetration, slow progress, excessive piling of weld metal and slag inclusion

C. High current: excessive spatter and undercutting of weld joints

D. High voltage: poor penetration with flat bead; weld zone not shielded

E. Low voltage: poor penetration and humped bead

F. Slow speed: excessive heat and piling up of weld metal leading to unnecessary distortion of joint

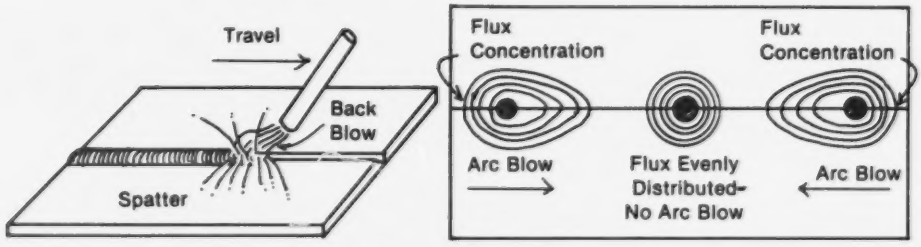
G. Rapid speed: irregular bead, poor penetration, undercut and insufficient weld metal in joint, causing a weak joint

II. Other factors in poor welds

A. Arc blow

1. Causes

a. Magnetic forces present with DC current build up lines of magnetism around the arc and cause it to blow wildly and spatter badly.



b. High amperage, thick plates, corners, deep grooves and the joint's start and finish are the major problem areas.

2. Solutions

   a. Reduce current or switch polarity.

   b. Change current to AC.

   c. Change location of ground clamp.

   d. Wrap ground cable around workpiece and pass ground current through it to neutralize magnetic field.

   e. Maintain a short arc.

B. Surface pinholes and porosity

1. Causes

   a. Travel speed too fast

   b. Base metal surface conditions

   c. Faulty electrodes

   d. High sulphur and other impurities

   e. Incorrect polarity

2. Solutions

   a. Keep puddle molten for a longer period so that the gases can boil out before the metal freezes.

   b. Try using a shorter arc length.

   c. Clean surface of base metals.

   d. Dry electrodes.

C. Undercutting

1. Causes

   a. Current too high

   b. Arc length too long

   c. Improper rod angle or manipulation

   d. Welding speed too fast

2. Solutions

   a. Reduce current.

   b. Shorten arc length.

   c. Change electrode angle so that the force of the arc helps fill undercut.

   d. Use an electrode that is smaller in diameter.

D. Weld spatter

   1. Causes

      a. Current (amps) too high

      b. Arc length too long

   2. Solutions

      a. Reduce current

      b. Reduce arc length

E. Incomplete penetration

   1. Causes

      a. Faulty joint design

      b. Welding speed too fast

      c. Insufficient welding current

      d. Electrode size too large

   2. Solutions

      a. Check root opening, root face dimension and root face angle.

      b. Reduce welding speed.

      c. Increase welding current.

      d. Use an electrode that is smaller in diameter.

F. Slag inclusion

   1. Causes

      a. Joint design, sharp V-shaped recess

      b. High flow rate of molten metal, rapid chilling, weld current too low

2. Solutions

   a. Increase the weld area size to allow weld to tie in completely with base metal.

   b. Use preheat and higher welding amperage.

G. Excessive weld build-up

1. Causes

   a. Welding travel speed too slow

   b. Wrong electrode movement

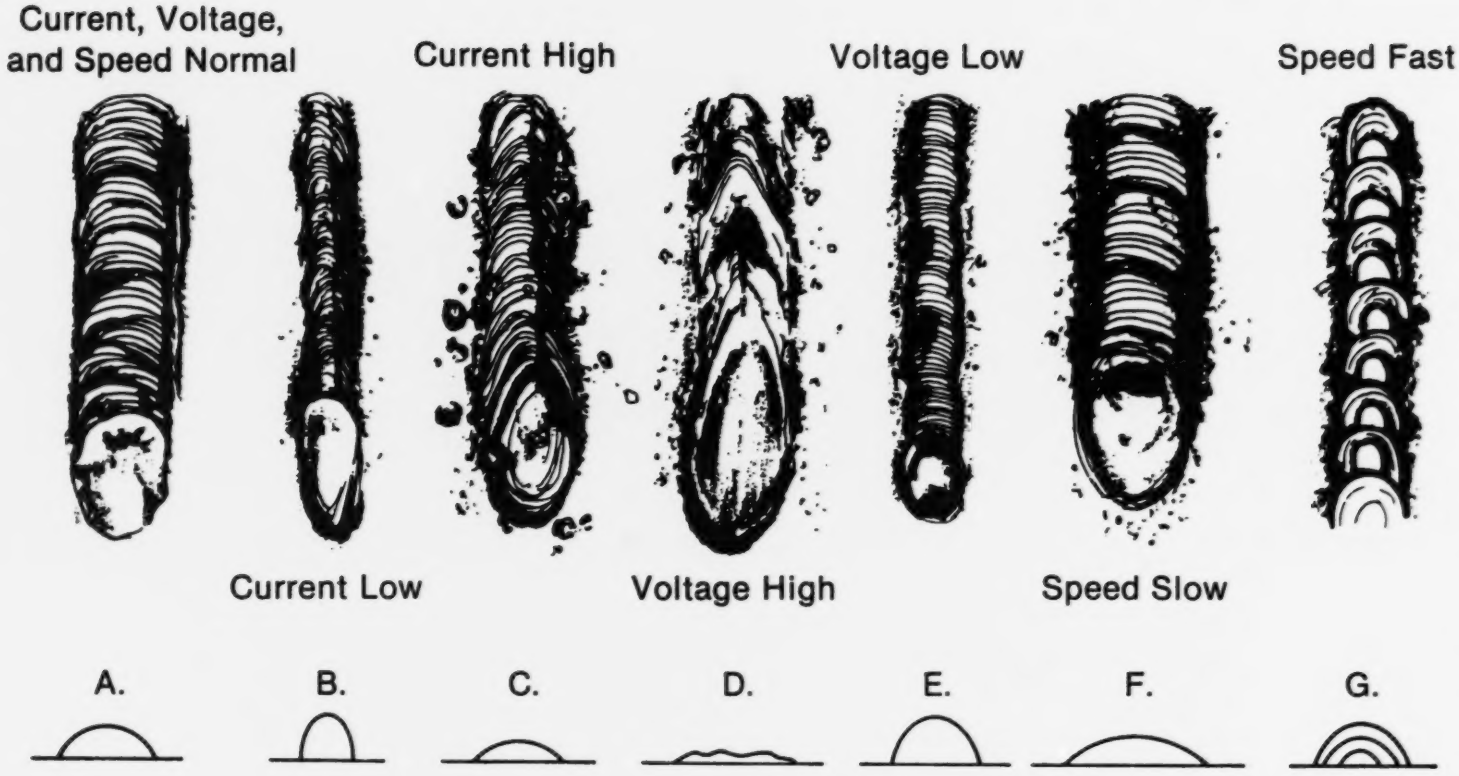
   c. Incorrect electrode size

2. Solutions

   a. Increase welding speed.

   b. Stabilize and maintain uniform travel speed.

   c. Choose electrode diameter comparable to base metal size.



GOOD AND BAD WELDS

TM 2.1

SMAW 55

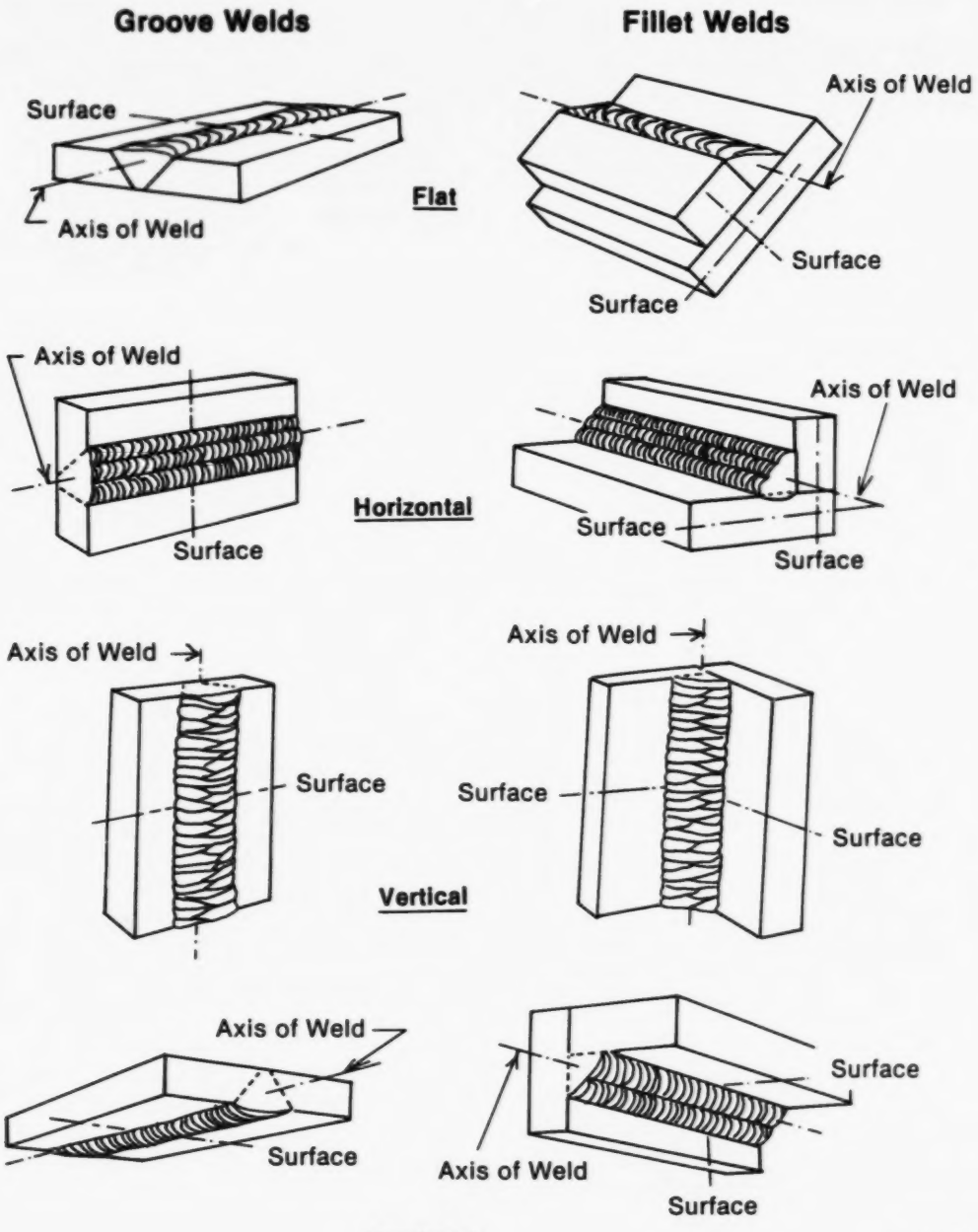
MODULE: SHIELDED METAL ARC WELDING

UNIT III: PREPARATION, PROBLEMS AND TECHNIQUES

LESSON 3: ELECTRODE ANGLES AND SMAW TECHNIQUES

I. Electrode angles

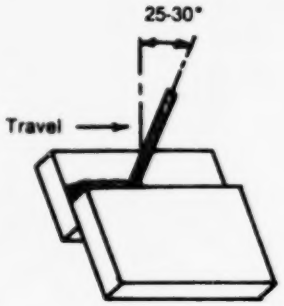
A. Electrode angles express the relationship of an electrode to both the weld axis and the base metal's surface(s).



SMAW 57

B. Travel angle is the angle of an electrode in relation to the weld axis when the electrode is perpendicular to the axis.

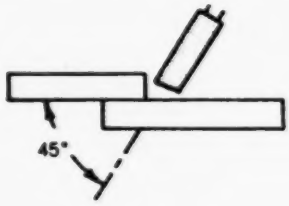
NOTE: In the job sheet that follows this unit, travel angle is usually represented in a side view.



Side View

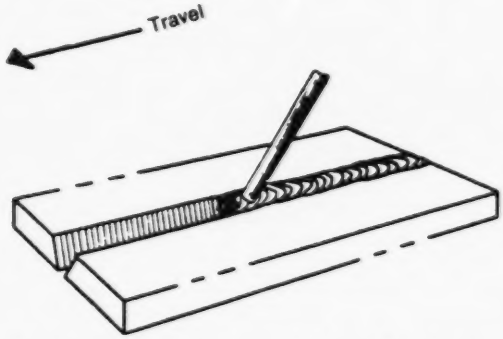
C. Work angle is the electrode angle in relation to the base metal's surface when the electrode is perpendicular to the weld axis.

NOTE: In the job sheet that follows this unit, work angle can be presented in an end, top or bottom view.



End View

D. Push angle is the angle of an electrode when it is pointed in the direction of welding; the forehand technique is used.



E. Drag angle is the electrode's angle when it is pointed opposite to the direction of welding; the backhand technique is used.

II. SMAW techniques

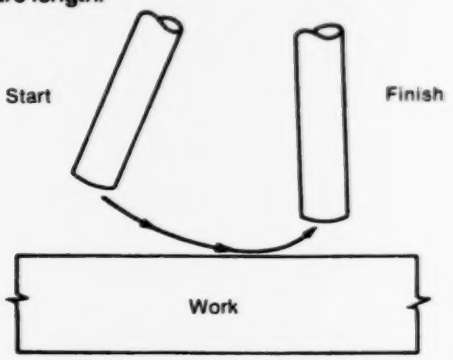
A. The technique most basic to all arc welding is to strike and maintain an arc so that the current is forced across a gap between the electrode tip and the base metal. Beginners should develop the skill of striking and maintaining an arc with a proper gap or arc length.

B. The scratch method for striking an arc is the simplest method for beginners, especially when they are using an AC machine.

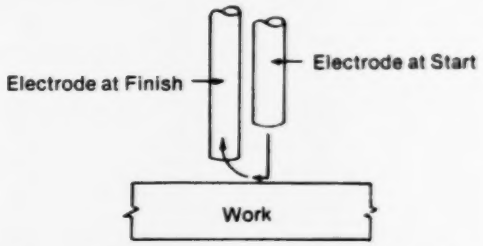
1. Move the electrode across the base metal at an angle used to strike a match.

2. As the electrode scratches the base metal, an arc is struck.

3. When the arc is struck, raise the electrode slightly to make a long arc. Then return to the normal arc length.



C. The tap method for striking an arc is accomplished by moving the electrode downward in a vertical direction until it just taps the base metal, then raising it up slightly to form a long arc. Return it to normal arc length.



D. Arc gap should usually be slightly less than the diameter of the electrode (about 0" to 1/8").

E. Too much arc gap can usually be identified by a hissing sound, as opposed to a crackling sound. Too much gap also causes excess spatter and poor penetration. The filler metal will melt off in large wobbly drops; slag will be difficult to remove.

F. With insufficient arc gap, the arc won't start or the electrode may freeze to the weld puddle and stick there.

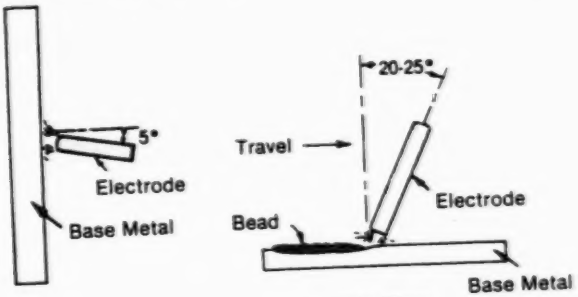
G. A too-quick operating speed will produce a thin, stringy bead with poor penetration.

H. A too-slow operating speed will produce a humped bead with excessive overlap.

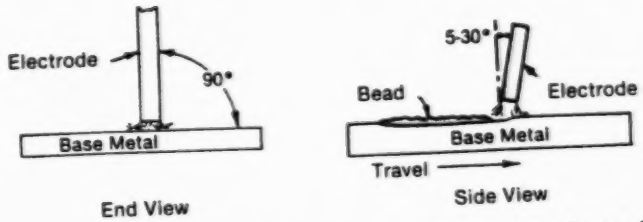
I. Electrode angle varies with electrode selection and welding position, but a few rules of thumb exist.

1. For right-hand welding of flat beads, place the electrode at a 90-degree angle, then lean it 5-30 degrees to the right so that it is pointed in the direction of travel.

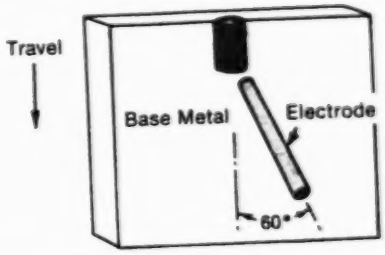
2. For left-handed flat bead welding, reverse the above procedure.



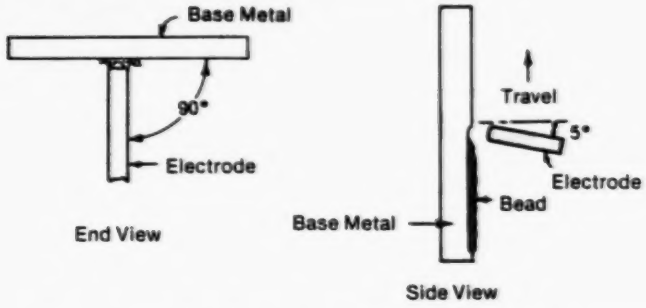
J. When welding in the horizontal position, angle the electrode 20-25 degrees in the direction of travel.



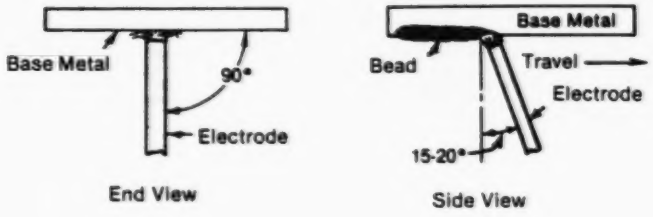
K. When welding in the vertical down position, point the electrode up at an angle of about 60 degrees from the base metal.



L. When welding in the vertical up position, hold electrode five degrees below perpendicular and at a 90-degree angle from base metal.



M. When welding in the overhead position, hold the electrode perpendicular to the base metal at 90 degrees and incline it 15-20 degrees in the direction of travel.

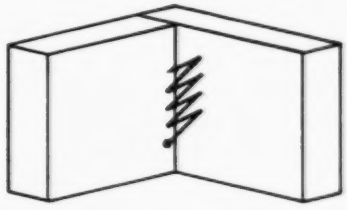


III. Bead running techniques and procedures (TM 3.1)

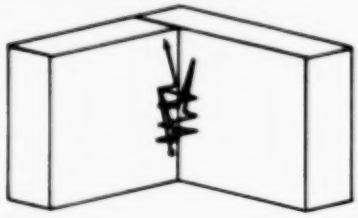
A. Drag: used with high-deposit, fast-fill electrodes. Consists of lightly dragging electrode tip along base metal to force molten filler metal uniformly out from under the electrode tip, which provides good penetration.

NOTE: When perfected, the drag technique can produce welds so smooth and uniform they look as if they were machine-made.

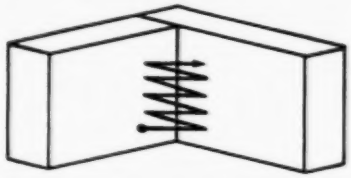
B. Whipping: used with fast-freeze electrodes to make stringer beads in all positions and on all types of joints. Consists of maintaining a short arc when in the crater and a long arc as the electrode is drawn out of the crater so the molten pool stays small and allows the filler metal to freeze quickly. This keeps the metal from spilling through the joint.



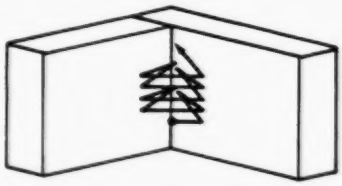
C. Whipping with slight weave in the crater: used with fast-freeze electrodes to make the first pass on vertical fillet and V-groove butt welds



D. Side-to-side weave: used with all types of electrodes to make fill passes on vertical fillet and V-groove butt welds. Sometimes also used with full-freeze and low-hydrogen electrodes to make the first pass on these joints

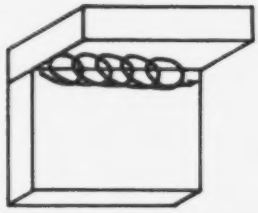


E. Triangular weave: used with full-freeze and low-hydrogen electrodes to make the first pass on vertical fillet and V-groove butt welds because it provides a larger weld than a side-to-side weave.



F. Box weave: used with all types of electrodes to make the fill pass on vertical fillet and V-groove butt welds. It is similar to the side-to-side weave but has a distinct pause and slight upward motion at each edge of the weld to assure complete crater fill-up and eliminate undercutting.

G. Circular motion: used with all types of electrodes to make overhead welds.



H. Stringer bead: used with certain types of electrodes. Consists of a minimal weaving motion used in all welding positions.

IV. Procedure for restarting an arc

A. Anticipate the point where the rod is going to be used up or where welding will stop, then break the arc with the following procedure.

1. Stop the forward motion of the electrode.

2. Allow the crater to fill.

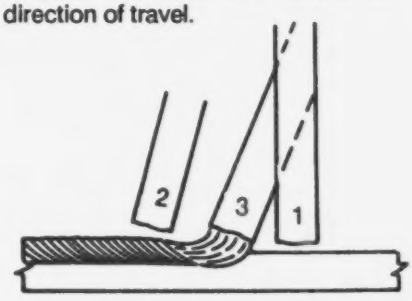
3. Gradually withdraw the electrode to break the arc.

B. Chip the slag off the end of the weld about 1/4" to 1/2" back.

C. Restart the arc.

1. Restrike the arc at the forward end of the crater or just in front of the forward end of the crater.

2. Move the electrode quickly back to the back crown of the crater and immediately resume welding in the direction of travel.



D. If the process is properly executed, any marks left by restarting the arc ahead of the crater will be covered as the bead is continued.

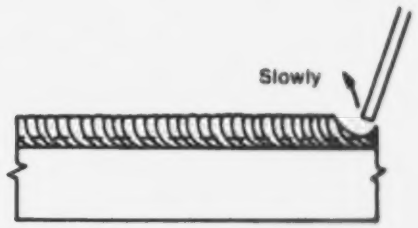
NOTE: Restarting an arc is a frequent requirement in arc welding. Beginners need to practice the technique until they can do it well.

E. Using feathered edges for tie-ins

1. To assure a good tie-in when restarting a bead or when starting from a tack weld, the tie-in point should always be chipped and brushed.

2. When a weld deposit is too large to make a normal tie-in, the end of the first bead or the end of the tack weld can be ground and feathered.

3. Grinding and feathering means using a hand grinder to smoothly round the sides near the end of the bead or tack weld, then grinding the end of the bead to a sloping sharp edge.

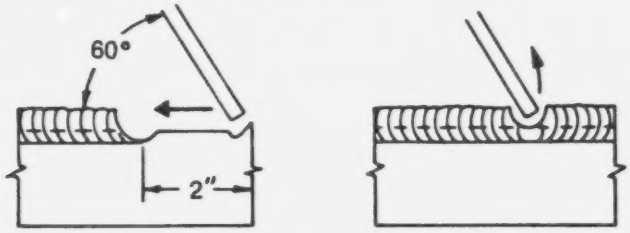


4. Grinding and feathering is sometimes called for in specifications. The process is used on some root passes in pipe welding and is necessary on some V-groove welds.

V. Filling a crater at the end of a weld

A. Procedure A

1. Just before the bead reaches the end of the plate, draw the electrode slowly up and slightly backward over the completed weld.



2. Make sure the motion is slow enough to allow the crater to fill and that the backward motion is far enough so that the crater remains on top of the bead about 1/4" to 1/2" back from the end of the weld.

B. Procedure B

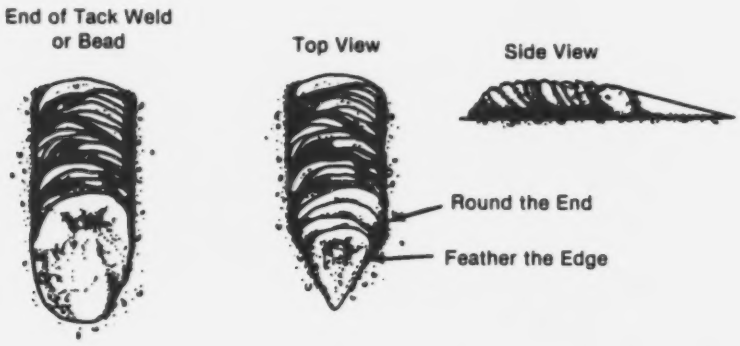
1. Break the arc about 1" or 2" from the end of the weld by quickly shortening the arc and pulling it sideways out of the crater.

2. Chip and remove slag from the end of the bead.

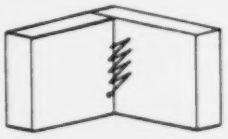
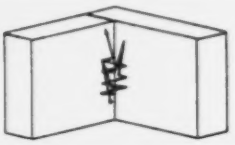
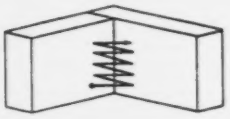
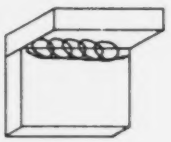
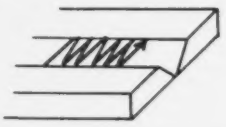
3. Move to the end of the plate, restrike the arc and weld back toward the bead.

4. Incline the electrode about 60 degrees in the direction of travel.

5. Weld back over the crater and stop the arc by pulling up and slightly backwards as the two beads run together and the crater forms properly on top of the bead.



BASIC MOTIONS FOR ELECTRODE MANIPULATION

Motion	Illustration
Straight Whipping Motion	
Whipping Motion with Slight Weave in Crater	
Vertical Side-to-Side Weave	
Triangular Weave	
Box Weave	
Circular Motion	
Flat Side-to-Side Weave	

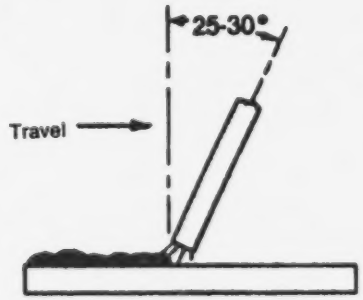
STRIKE AND RESTART ARC; CRATER AND BACKFILL AT EDGE OF PLATE

Equipment:

SMAW machine with accessories
SMAW electrode(s), as selected by instructor
Mild steel plates, as selected by instructor
Personal safety clothing and arc welding equipment
Pliers
Chipping hammer
Wire brush
Safety glasses

Procedure:	Evaluation 3 2 1 N
1. Inspect work area to make sure it is free of flammable materials and is well ventilated. Note the location of the nearest fire extinguisher.	— — — —
2. Attach ground clamp to work table or workpiece. Select correct polarity for electrode. Turn on SMAW machine.	— — — —
3. Set machine to recommended amperage setting. Place electrode in holder at a 90-degree angle.	— — — —
4. Place metal on work table directly in front of you. Move electrode down close to the base metal, being careful not to strike an arc. Lower welding hood to a safe operating position.	— — — —
5. Strike arc by moving electrode across base metal at an angle similar to striking a match. To form a long arc, withdraw electrode just as arc is struck. Then, lower electrode to a normal arc length of 0-1/8".	— — — —
6. Make the bead while holding the electrode perpendicular to the plate at an angle of 25-30 degrees in the direction of travel.	— — — —

NOTE: If right-handed, weld from left to right. If left-handed, weld from right to left.



7. Weld a bead about half the length of the plate. Then, purposely top the weld with the following procedure. — — — —

   a. Stop the forward motion of the electrode.

   b. Allow the crater to fill.

   c. Gradually withdraw electrode to break the arc.

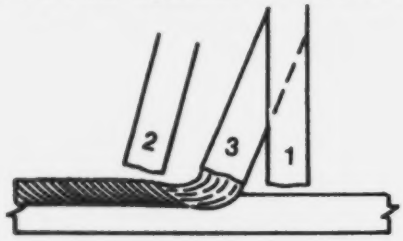
8. Chip slag off the end of the weld about 1/4" back. — — — —

   CAUTION: Always wear safety glasses when working with a chipping hammer.

9. Restart the arc with the following procedure. — — — —

   a. Restrike arc at or just in front of the forward end of the crater.

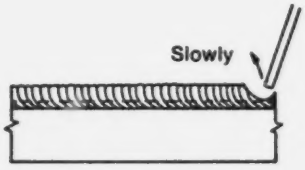
   b. Move the electrode quickly to the back crown of the crater and immediately resume welding in the direction of travel.



10. Continue welding until the bead reaches the end of the plate. Then crater and backfill. — — — —

    a. Draw the electrode slowly up and slightly backward over the completed weld.

    b. Make sure the motion is slow enough to allow the crater to fill and that the backward motion is fast enough that the crater remains on top of the bead about 1/4-1/2" back from the weld's end.



11. Take electrode from holder and place holder on hook. Secure workpiece with pliers and clean the weld thoroughly with a chipping hammer and wire brush. — — — —

12. Inspect weld for bead width, undercut, spatter, poor fusion and other irregularities. Check restart point. Inspect crater and backfill at the weld edge. — — — —

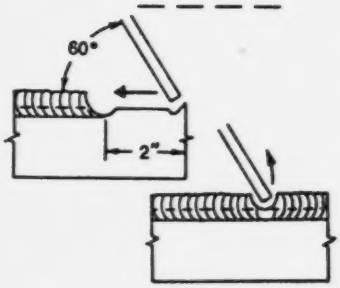
13. Ask instructor to check your work. — — — —

14. Take electrode holder and reinsert electrode or start with a new one. Strike arc and run another bead. — — — —

15. Stop the forward motion of the electrode midpoint in the bead. Allow the crater to fill. Gradually withdraw the electrode to break the arc. — — — —

16. Chip slag off crater. Restart arc and continue welding as previously outlined. This time, break the arc about 1-2" from the end of the plate. — — — —

17. Crater and backfill. — — — —



a. Chip and remove slag from the end of bead.

b. Move to the end of the plate. Restrike the arc and weld back toward the bead.

c. Incline the electrode about 60 degrees in the direction of travel.

d. Weld back over the crater and stop the arc by pulling up and slightly backward as the two beads run together.

18. Take electrode from holder and place holder on hook. Secure work-piece with pliers and clean weld thoroughly with a chipping hammer and wire brush. — — — —

19. Inspect weld for bead width, undercut, spatter, poor fusion and other irregularities. Check restart point. Inspect crater and backfill at edge of weld. — — — —

20. Ask instructor to check your work. — — — —

21. Compare the two beads just welded, paying special attention to restart points and bead ends. Discuss with your instructor the crater and backfill technique with which you felt most comfortable. — — — —

22. Turn off machine. Repeat procedure for practice or clean up area and return tools and materials, as directed by your instructor. — — — —

Average of above evaluations* — — — —

*This average is the student's partial evaluation for competency E6: Identify welding problems, their causes, and take corrective action.

MODULE: SHIELDED METAL ARC WELDING

UNIT III: PREPARATION, PROBLEMS AND TECHNIQUES

UNIT TEST

Match the term, weld characteristic or electrode angle on the right with its appropriate description on the left.

____ 1.	Smooth, well-formed bead with no undercutting, overlapping or piling of slag	a.	Beveling
____ 2.	Poor penetration, slow progress, excessive piling of weld metal and slag inclusion	b.	Drag angle
____ 3.	Excessive spatter and undercutting of weld joints	c.	Electrode angle
____ 4.	Poor penetration with flat bead; weld zone not shielded	d.	Rapid speed
____ 5.	Poor penetration and humped bead	e.	Grinding
____ 6.	Excessive heat and piling up of weld metal leading to unnecessary distortion of joint	ab.	High current
____ 7.	Irregular bead, poor penetration, undercut and not enough weld metal in joint causing a weak joint	ac.	High voltage
____ 8.	Express the relationship of an electrode to both the weld axis and the base metal's surface(s)	ad.	Low current
____ 9.	Angle of an electrode in relation to the weld axis when the electrode is perpendicular to the axis	ae.	Low voltage
____ 10.	Angle of an electrode in relation to the base metal's surface(s) when the electrode is perpendicular to the weld axis	bc.	Normal current, voltage and speed
____ 11.	Angle of an electrode when it is in the direction of welding; forehand technique used	bd.	Push angle
____ 12.	Angle of an electrode when it is pointed opposite the direction of welding; backhand technique used	be.	Slow speed
____ 13.	Putting angles on pieces of material to aid penetration when welded	cd.	Travel angle
____ 14.	Use of an abrasive device to remove metal or slag from welded area	ce.	Work angle

___ 15. The two most common ways to prepare metal for welding (joint preparation) are ____ ____ .

a. Sawing and filing
b. Sawing and grinding
c. Grinding and whittling
d. Grinding and beveling

___ 16. The technique most basic to all arc welding is to strike and maintain an arc so that _____ .

a. The current is forced across a gap between the electrode tip and the base metal
b. The electrical flow from plate to electrode welds the pieces together
c. The electrical flow from electrode to plate welds the pieces together
d. All of the above
e. None of the above

___ 17. Arc gap should usually be _____ the diameter of the electrode.

a. Slightly more than
b. The same as
c. Slightly less than
d. About one-half

___ 18. Too much arc gap can usually be identified by a _____ .

a. Crackling sound
b. Spatter absence on plate
c. Smooth, even electrical arc
d. Hissing sound

___ 19. What causes excess spatter and poor penetration, filler metal melting off in large wobbly drops and no slag formation?

a. Too little arc gap
b. Too much arc gap
c. The wrong sized electrode
d. Excessive power setting

___ 20. Which bead running technique is used with high-deposit, fast-fill electrodes and can result in a very smooth, uniform bead?

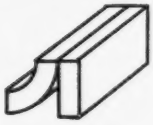
a. Drag
b. Whipping
c. Side-to-side weave
d. Triangular weave

___ 21. Which bead running technique is used with all types of electrodes to make overhead welds?

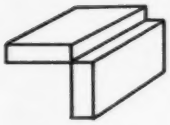
a. Triangular weave
b. Box weave
c. Circular motion
d. Side-to-side weave

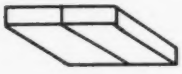
Identify the following joints.

___ 22.

___ 23. 

___ 24.

___ 25. 

___ 26. 

a. Lap

b. T

c. Butt

d. Edge

e. Corner

27. Beside those given in the matching questions, list four other factors in poor welds.

a.

b.

c.

d.

NOTE: Completion of this test to a specified score is the student's final evaluation for competencies E5 and E6.

ANSWERS TO UNIT TEST

1. bc (E6)
2. ad (E6)
3. ab (E6)
4. ac (E6)
5. ae (E6)
6. be (E6)
7. d (E7)
8. c
9. cd
10. ce
11. bd
12. b
13. a (E5)
14. e (E5)
15. d (E5)
16. a (E6)
17. c (E6)
18. d (E6)
19. b (E6)
20. a (E5)
21. c (E5)
22. b (E5)
23. d (E5)
24. a (E5)
25. e (E5)
26. c (E5)

27. Any four of the following: (E5)
    Arc blow
    Surface pinholes and porosity
    Undercutting
    Weld spatter
    Incomplete penetration
    Slag inclusions
    Excessive weld build-up

MODULE: SHIELDED METAL ARC WELDING

UNIT IV: BUILDING PADS OF BEADS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to build pads of beads using assigned electrodes in various positions. This knowledge will be evidenced by completion of job sheets to specified score.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student will be able to:

1.1 Build a pad of beads in flat position using these electrodes: E6010 or 6011, E7018 and E7024.

1.2 Build a pad of beads in horizontal position using E6010 or 6011 and E7018.

1.3 Build a pad of beads in vertical position using E6010 or 6011 and E7018.

1.4 Build a pad of beads in overhead position using E6010 or 6011 and E7018.

MODULE: SHIELDED METAL ARC WELDING

UNIT IV: BUILDING PADS OF BEADS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: BUILDING PADS OF BEADS

   a. Information outline

   b. Job sheets

      JS 1.1: Build a pad of beads in flat position
      JS 1.2: Build a pad of beads in horizontal position
      JS 1.3: Build a pad of beads in vertical position
      JS 1.4: Build a pad of beads in overhead position

REFERENCES

A. Books

1. Giachino, Joseph and William Weeks. Welding Skills and Practices. Chicago: American Technical Publishers, Inc., 1976.

2. Horwitz, Henry. Welding Principles and Practices. Boston: Houghton Mifflin Company, 1979.

3. Sacks, J. Raymond. Welding Principles and Practices. Peoria, Ill.: Charles A. Bennett Co., Inc., 1976.

B. Curriculum guide

1. Fortney, Clarence, and Mike Gregory. Shielded Metal Arc Welding. Stillwater, Okla.: Mid-America Vocational Curriculum Consortium, Inc., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. If pad building is less important in your area than fillet welding, cover material in this unit lightly. SMAW fillet welding is covered in Unit VI.

2. Pad building is not usually an essential skill an employer looks for, but it is a method that can be used to train students in a cost-effective way. Students can weld on one or two plates for several days or until you feel they are ready to move forward to the next step.

3. In addition to using job sheets to assess procedure, data on the pads' weight, thickness and quality can be gathered for each student. If possible, obtain plates that weigh about the same (two ounces). At the beginning of each day, weigh the students' plates. Keep a daily record in columnar form.

Student Name	Day 1	Day 2	Day 3	Day 4	Day 5

At the end of a given time period, have the students stop welding on their pads.

* Instruct them to cut the pads in half or along a line you designate. (Make the cut either by flame cutting or sawing.)
* Grind the face of one of the cut halves smooth and flat.
* Use a polishing or fine-sanding disk to bring the cut face to a polish where mistakes (cold lap, slag, uneven weld, etc.) are clearly visible.
* Count all mistakes and subtract from 100 (total points for shop exam).

4. To compensate for quality and quantity, use the completed chart to find the daily average weight gain per student. Now find the difference from average to best (or heaviest gain/day), and you have a basic C-A curve. Calculate the other direction from C-F. Set it up so that every 10 mistakes in a cut face drops the student's score one letter grade from where the plate's weight started.

The sample below illustrates this suggested grading method.

Student name	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Total gain	Errors
Larry	3	5	6.75	8	10.25	15	16	16.5	13.5	28
Jim	3	5	7	9	10.5	--	12.5	14	11	17
Joe	3	4	4.75	6	7	8	9	11	8	10
Jill	3	5	7	9	11	13	14	15	12	11

a. Total all plates' total weight (16.5 + 14 + 11 + 15 = 57 lbs.)
b. 57 - 12 (beg. wt.) = 45 lbs. total gain
c. 45 lbs. / 4 (no. of students) = 11.25 lbs. ave. gain/student
d. 11.25 / 7 (no. of working days) = 1.607 or 1.61 lbs. ave. daily gain
e. Find student with highest weight.
f. Find 60% of that student's total gain (13.5 x .60 = 8.10)
g. 8.10 lbs. becomes the D-F line.

h. Figure grade breaks for your scale.
i. Now subtract mistakes from letter grade (10 mistakes for each letter grade drop).

5. Make sure students clean first pass or passes before welding pad beads. Demonstrate the overhead method several times during these jobs.

MODULE: SHIELDED METAL ARC WELDING

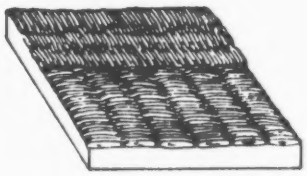
UNIT IV: BUILDING PADS OF BEADS

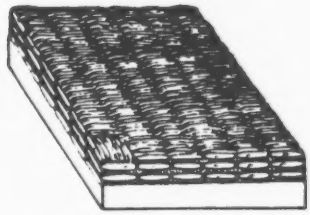
LESSON 1: BUILDING A PAD OF BEADS

I. Padding

1. Used with all types of electrodes to build up metal surfaces with one or more layers of weld beads.

2. Padding can be used on flat or curved surfaces as overlapping straight beads or overlapping weave beads.





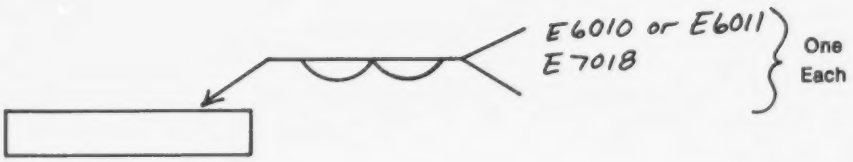
BUILD A PAD ON MILD STEEL PLATE IN THE FLAT POSITION

Equipment:

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates, as selected by instructor
Safety glasses

Specifications:

Plate and weld symbol

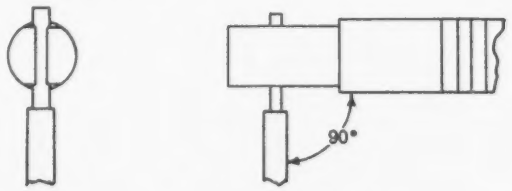


Position: flat
Cleaning: chip and wire brush after each bead
Testing: visual
Technique: whipping for E6010 or 6011; drag for E7018 and 7024
References: AWS A2.4-79 (10.2) and AWS B3.0-77 (4.2)

Procedure:

Evaluation
3 2 1 N

1. Place electrode in holder as indicated. — — — —

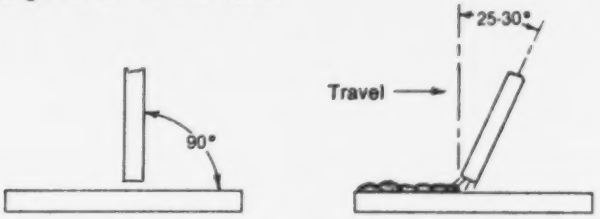


End View Side View

2. Place metal on work table directly in front of you. Move electrode down close to the base metal, being careful not to strike an arc. Lower your welding hood to a safe operating position. — — — —

3. Strike an arc by moving the electrode across the base metal at about the same angle as if striking a match. Withdraw the electrode just as the arc is struck to form a normal arc length (about 0-1/8"). — — — —

4. Make the bead while holding the electrode at an angle of 25-30 degrees in the direction of travel, using a whipping technique for E6010 or 6011 and a dragging angle for E7018 and 7024. — — — —



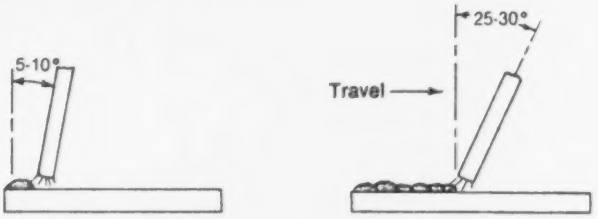
5. Crater and backfill at the edge of the plate. Take electrode from holder and place holder on hook. — — — —

6. Secure workpiece with pliers and clean weld thoroughly with the chipping hammer and wire brush. Inspect weld for bead width, undercut, spatter and poor fusion and other defects. — — — —

7. Ask instructor to check your work. — — — —

8. Reinsert electrode in holder and position yourself properly over the workpiece. — — — —

9. Start the second bead at the toe of the first bead so that the toe of the second bead laps to the center of the first bead. The electrode should be 5-10 degrees short of perpendicular. — — — —

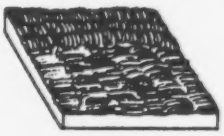


10. Continue using the whipping technique to complete second bead so that it is the same length as the first bead. Stop, clean and inspect. — — — —

11. Continue making beads as required to cover the plate by starting at the toe of each preceding bead. Keep the electrode adjusted at 5-10 degrees short of perpendicular. Clean each bead thoroughly and inspect for defects. — — — —

12. Complete first layer of beads and inspect the pad. — — — —

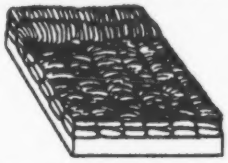
13. Turn the workpiece at a 90-degree angle and weld the first bead on the second layer using the same whipping technique as used on the first layer. — — — —



14. Clean and inspect first bead on the second layer. Continue with all beads on the second layer, being sure to adjust electrode angle and continue using the whipping technique with each bead. Clean and inspect each bead. — — — —

15. Ask instructor to check your completed second layer. — — — —

16. Turn the workpiece at a 90-degree angle and weld the first bead of the third layer the same as the first beads on previous layers. — — — —



17. Clean and inspect the first bead of the third layer. Continue making beads to complete the third layer on the pad. Adjust electrode angle as required. Continue to use the whipping technique. Complete, clean, and inspect third layer. — — — —

18. Ask instructor to check your work. — — — —

19. Continue adding layers to the pad as directed by your instructor. Stop after each layer and ask your instructor to check your work. — — — —

20. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competencies E7-E9.

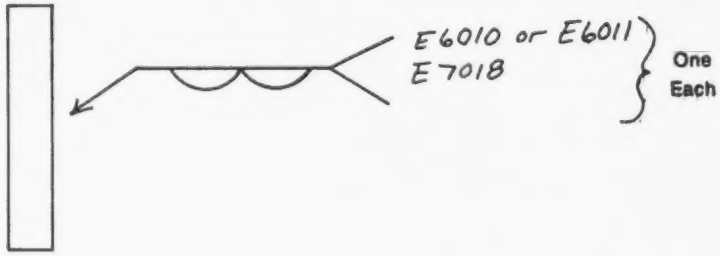
BUILD A PAD OF BEADS IN HORIZONTAL POSITION

Equipment:

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates, as selected by instructor
Safety glasses

Specifications:

Plate and weld symbol

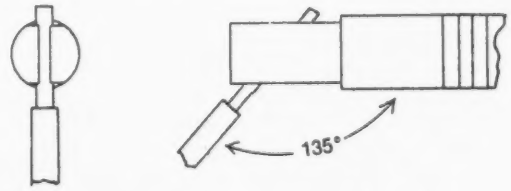


Position: horizontal
Cleaning: chip and wire brush after each bead
Testing: visual
Technique: whipping for E6010 or 6011; drag for E7018
References: AWS A2.4-79 (10.2) and AWS B3.0-77 (4.2)

Procedure:

Evaluation
3 2 1 N

1. Place electrode in holder as indicated. — — — —

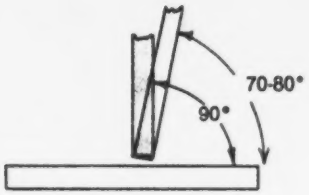


End View Side View

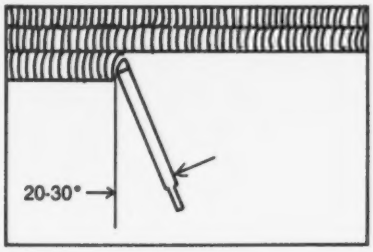
2. Place metal on work table directly in front of you. Move electrode down close to the base metal, being careful not to strike an arc. Lower your welding hood to a safe operating position. — — — —

3. Strike an arc by moving the electrode across the base metal at about the same angle as if striking a match. Withdraw the electrode just as the arc is struck to form a normal arc length (about 0-1/8"). — — — —

4. Make the bead while holding the electrode in the direction of travel at an angle of 25-30 degrees from perpendicular, using a whipping technique for E6010 or 6011 and a dragging angle for E7018. — — — —



End View



Front View

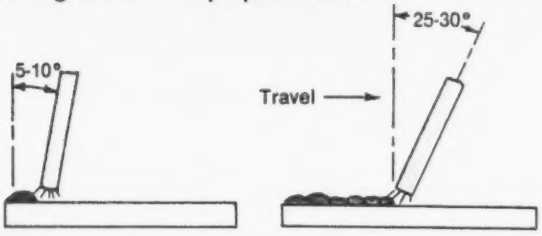
5. Crater and backfill at the edge of the plate. Take electrode from holder and place holder on hook. — — — —

6. Secure workpiece with pliers and clean weld thoroughly with the chipping hammer and wire brush. Inspect weld for bead width, undercut, spatter, poor fusion and other defects. — — — —

7. Ask instructor to check your work. — — — —

8. Reinsert electrode in holder and position yourself properly over the workpiece. — — — —

9. Start the second bead at the toe of the first bead so that the toe of the second bead laps to the center of the first bead. The electrode should be 5-10 degrees short of perpendicular. — — — —

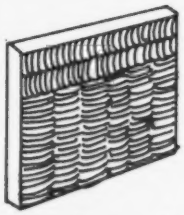


10. Continue using the whipping technique to complete second bead so that it is the same length as the first bead. Stop, clean and inspect. — — — —

11. Continue making beads as required to cover the plate by starting at the toe of each preceding bead. Keep the electrode adjusted at 5-10 degrees short of perpendicular. Clean each bead thoroughly and inspect for defects. — — — —

12. Complete first layer of beads and inspect the pad. — — — —

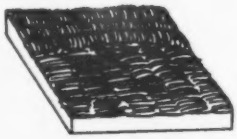
13. Turn the workpiece at a 90-degree angle and weld the first bead on the second layer using the same whipping technique as used on the first layer. — — — —



14. Clean and inspect first bead on the second layer. Continue with all beads on the second layer, being sure to adjust electrode angle and continuing to use the whipping technique with each bead. Clean and inspect each bead. — — — —

15. Ask instructor to check your completed second layer. — — — —

16. Turn the workpiece at a 90-degree angle and weld the first bead of the third layer the same as the first beads on previous layers. — — — —



17. Clean and inspect the first bead of the third layer. Continue making beads to complete the third layer on the pad. Adjust electrode angle as required. Continue to use the whipping technique. Complete, clean, and inspect third layer. — — — —

18. Ask instructor to check your work. — — — —

19. Continue adding layers to the pad as directed by your instructor. Stop after each layer and ask instructor to check your work. — — — —

20. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competencies E10 and E11.

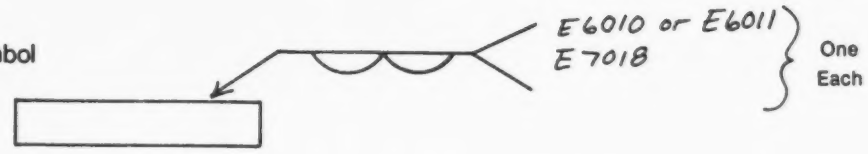
BUILD A PAD OF BEADS IN VERTICAL POSITION

Tools and materials:

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates, as selected by instructor
Safety glasses

Specifications:

Plate and weld symbol

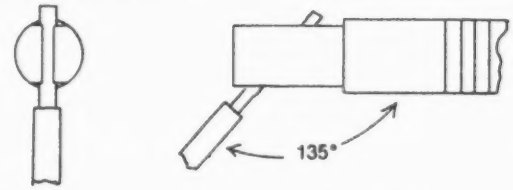


Position: vertical
Cleaning: chip and wire brush after each bead
Testing: visual
Technique: whipping for E6010 or 6011; drag for E7018
References: AWS A2.4-79 (10.2) and AWS B3.0-77 (4.2)

Procedure:

Evaluation
3 2 1 N

1. Place electrode in holder as indicated. — — — —

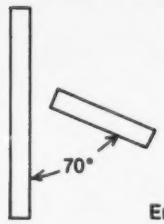


End View Side View

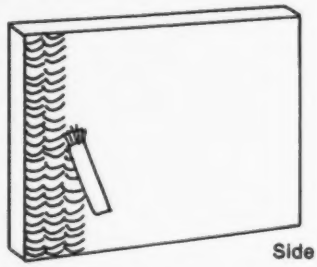
2. Place metal on work table directly in front of you. Move electrode down close to the base metal, being careful not to strike an arc. Lower your welding hood to a safe operating position. — — — —

3. Strike an arc by moving the electrode across the base metal at about the same angle as if striking a match. Withdraw the electrode just as the arc is struck to form a normal arc length (0-1/8"). — — — —

4. Make the bead while holding the electrode 25-30 degrees from perpendicular in the direction of travel, using a whipping technique for E6010 or 6011 and a dragging angle for E7018. — — — —



End View


Side View

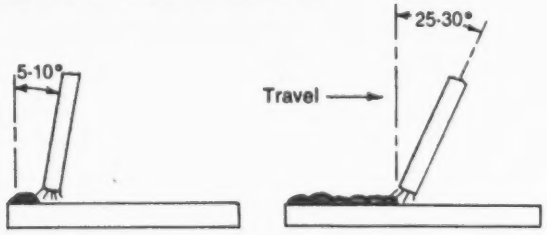
5. Crater and backfill at the edge of the plate. Take electrode from holder and place holder on hook. — — — —

6. Secure workpiece with pliers and clean weld thoroughly with the chipping hammer and wire brush. Inspect weld for bead width, undercut, spatter, poor fusion and other defects. — — — —

7. Ask instructor to check your work. — — — —

8. Reinsert electrode in holder and position yourself properly over the workpiece. — — — —

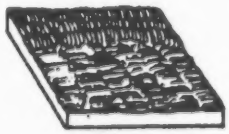
9. Start the second bead at the toe of the first bead so that the toe of the second bead laps to the center of the first bead. The electrode should be 5-10 degrees short of perpendicular. — — — —



10. Continue using the whipping technique to complete second bead so that it is the same length as the first one. Stop, clean and inspect. — — — —

11. Continue making beads as required to cover the plate by starting at the toe of each preceding bead and keep the electrode adjusted at 5-10 degrees short of perpendicular. Clean each bead thoroughly and inspect for defects. — — — —

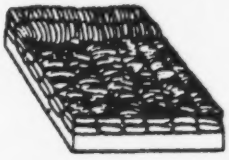
12. Complete first layer of beads and inspect the pad. Turn the workpiece at a 90-degree angle and weld the first bead on the second layer using the same whipping technique as used on the first layer. — — — —



13. Clean and inspect first bead on the second layer. Continue with all beads on the second layer, being sure to adjust electrode angle and continuing to use the whipping technique with each bead. Clean and inspect each bead. — — — —

14. Ask instructor to check your completed second layer. — — — —

15. Turn the workpiece at a 90-degree angle and weld the first bead of the third layer the same as the first beads on previous layers. — — — —



16. Clean and inspect the first bead of the third layer. Continue making beads to complete the third layer on the pad. Adjust electrode angle as required. Continue to use the whipping technique. Complete, clean, and inspect third layer. — — — —

17. Ask instructor to check your work. — — — —

18. Continue adding layers to the pad as directed by your instructor. Stop after each layer and ask instructor to check your work. — — — —

19. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competencies E12 and E13.

BUILD A PAD OF BEADS IN OVERHEAD POSITION

Equipment:

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plates, as selected by instructor
Safety glasses

Specifications:

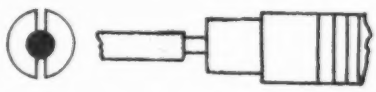
Plate and weld symbol

Position: overhead
Cleaning: chip and wire brush after each bead
Testing: visual
Technique: whipping for E6010 or 6011; drag for E7018
References: AWS A2.4-79 (10.2) and AWS B3.0-77 (4.2)

Procedure:

Evaluation
3 2 1 N

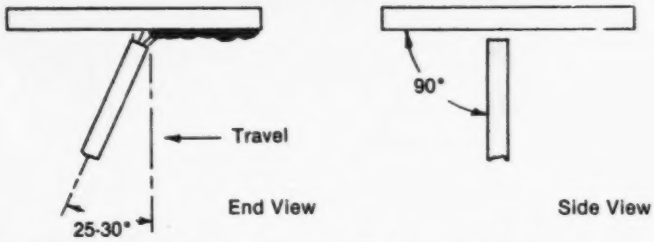
1. Place electrode in holder as indicated. — — — —



2. Place metal directly in front of you. Move electrode down close to the base metal, being careful not to strike an arc. Lower your welding hood to a safe operating position. — — — —

3. Strike an arc by moving the electrode across the base metal at about the same angle as if striking a match. Withdraw the electrode just as the arc is struck to form a normal arc length (0-1/8"). — — — —

4. Make the bead while holding the electrode at an angle of 25-30 degrees short of perpendicular in the direction of travel, using a whipping technique for E6010 or 6011 and a dragging angle for E7018. — — — —



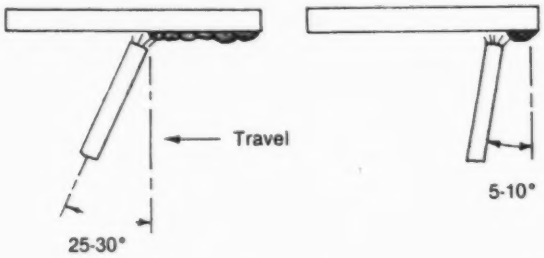
5. Crater and backfill at the edge of the plate. Take electrode from holder and place holder on hook. — — — —

6. Secure workpiece with pliers and clean weld thoroughly with the chipping hammer and wire brush. Inspect weld for bead width, undercut, spatter, poor fusion and other defects. — — — —

7. Ask instructor to check your work. — — — —

8. Reinsert electrode in holder and position yourself properly over the workpiece. — — — —

9. Start the second bead at the toe of the first bead so that the toe of the second bead laps to the center of the first bead. The electrode should be 5-10 degrees short of perpendicular. — — — —

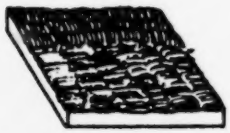


10. Continue using the whipping technique to complete second bead so that it is the same length as the first bead. Stop, clean and inspect. — — — —

11. Continue making beads as required to cover the plate by starting at the toe of each preceding bead and keep the electrode adjusted at 5-10 degrees short of perpendicular. Clean each bead thoroughly and inspect for defects. — — — —

12. Complete first layer of beads and inspect the pad. — — — —

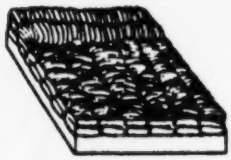
13. Turn the workpiece at a 90-degree angle and weld the first bead on the second layer using the same whipping technique as used on the first layer. — — — —



14. Clean and inspect first bead on the second layer. Continue with all beads on the second layer, being sure to adjust electrode angle and continuing to use the whipping technique with each bead. Clean and inspect each bead. — — — —

15. Ask instructor to check your completed second layer. — — — —

16. Turn the workpiece at a 90-degree angle and weld the first bead of the third layer the same as the first beads on previous layers. — — — —



17. Clean and inspect the first bead of the third layer. Continue making beads to complete the third layer on the pad. Adjust electrode angle as required. Continue to use the whipping technique. Complete, clean, and inspect third layer. — — — —

18. Ask instructor to check your work. — — — —

19. Continue adding layers to the pad as directed by your instructor. Stop after each layer and ask instructor check your work. — — — —

20. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competencies E14 and E15.

MODULE: SHIELDED METAL ARC WELDING

UNIT V: TESTING GROOVE WELDS

UNIT OBJECTIVES

Upon completion of this unit, the student should understand the basic theory of testing groove welds and be familiar with code material on defects. The student should bend test a welded V-groove joint. This knowledge will be evidenced by achieving the specified score on job sheets.

SPECIFIC OBJECTIVES

1.1 Identify code material on defects--what passes and what doesn't.

1.2 Perform a bend test on a welded V-groove joint.

MODULE: SHIELDED METAL ARC WELDING

UNIT V: TESTING GROOVE WELDS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: PROCEDURE FOR TESTING GROOVE WELDS

   a. Information outline

   b. Job sheet

      JS 1.1: Bend test a welded V-groove joint

REFERENCES

A. Books

1. Giachino, Joseph and William Weeks. Welding Skills and Practices. Chicago: American Technical Publishers, Inc., 1976.

B. Curriculum guides

1. Fortney, Clarence, and Mike Gregory. Shielded Metal Arc Welding. Stillwater, Okla.: Mid-America Vocational Curriculum Consortium, Inc., 1984.

2. Structural Welding Code--Steel (AWS code D1.1). Miami: American Welding Society, 1986.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Explain to students the need for weld testing and why various tests differ.

2. Refer to the GMAW module for additional code material on defects.

3. Test several welds made with different electrodes.

4. The instructor may wish to include pipe and fillet testing with this unit, as well.

B. Suggested supplemental materials

1. Structural Welding Code--Steel (AWS code D1.1). Miami: American Welding Society, 1988.

2. Sacks, Raymond J. Welding Principles and Practices. Peoria, Ill.: Charles A. Bennett Co., Inc., 1976.

MODULE: SHIELDED METAL ARC WELDING

UNIT V: TESTING GROOVE WELDS

LESSON 1: PROCEDURE FOR TESTING GROOVE WELDS

I. Types of testing

A. Non destructive

1. X-ray or radiographic

2. Ultrasonic or sonar

3. Die penetrates

4. Magnetic particle

B. Destructive

1. Bend tests

2. Torque tests

3. Tension tests

II. Criteria for passing structural test (AWS Structural Welding Code)

A. Reduced-section tension test (5.12.1): Tensile strength shall be no less than the minimum of the specified range of the base metal used.

B. Root-, face- and side-bend tests (5.12.2)

NOTE: Make sure specimens are wide enough and long enough to bend completely when bend-tested.

1. The convex surface of the bend test specimen shall be visually examined for surface discontinuities. For acceptance, the surface shall contain no discontinuities exceeding the following dimensions.

a. 1/8 in. (3.2mm) measured in any direction on the surface

b. 3/8 in. (9.5mm)--the sum of the greatest dimensions of all discontinuities exceeding 1/32 in. (0.8mm), but less than or equal to 1/8 in. (3.2mm)

c. 1/4 in. (6.4mm)--the maximum corner crack, except when that corner crack resulted from visible slag inclusion or other fusion type discontinuities, then the 1/8 in. (3.2mm) maximum shall apply

2. Specimens with corner cracks exceeding 1/4 in. (6.4mm) with no evidence of slag inclusions or other fusion type discontinuities shall be disregarded and a replacement test specimen from the original weldment shall be tested.

BEND TEST A WELDED V-GROOVE JOINT

Equipment:

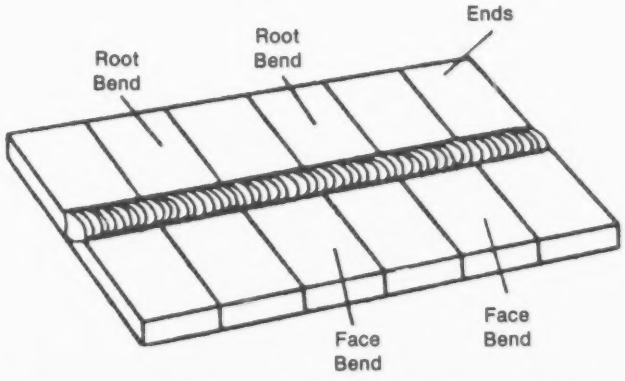
Bend test machine
Oxy-acetylene cutting unit
Portable hand grinder
File
Pliers
Groove-weld test plate, minimum 3/8" thickness
Personal safety clothing, equipment and safety glasses
Soapstone
Straight edge
Cutting goggles
Sparklighter

Procedure:

Evaluation
3 2 1 N

1. Check work area to make sure it is free of flammable materials and is well ventilated. Note the location of the nearest fire extinguisher.

2. Place test plate out on the work table in front of you and use the straight edge and soapstone to mark off bend specimens for a face bend, and a root bend. Mark specimens F and R for identification. — — — —



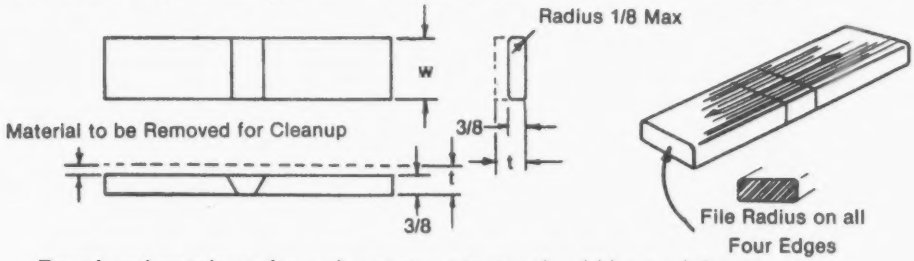
3. Set up oxy-acetylene equipment. Light and adjust cutting flame and cut specimens perpendicular to weld, as marked. — — — —

4. Turn off torch and shut down cutting unit. Permit specimens to air cool, but do not quench them in water or they will be unsuitable for testing. — — — —

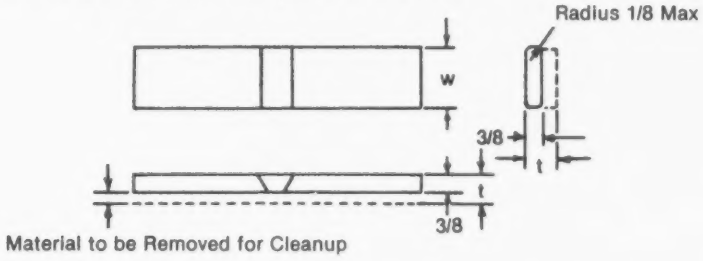
5. Take cooled specimens one at a time and secure in a vise. Use a portable grinder to grind to the following specifications. _____

   a. Face bend specimen for a plunger-type tester should be a minimum of 6" long, I 1/2" wide and ground lengthwise so that both the root and face of the weld are flush with the surface of the specimen.

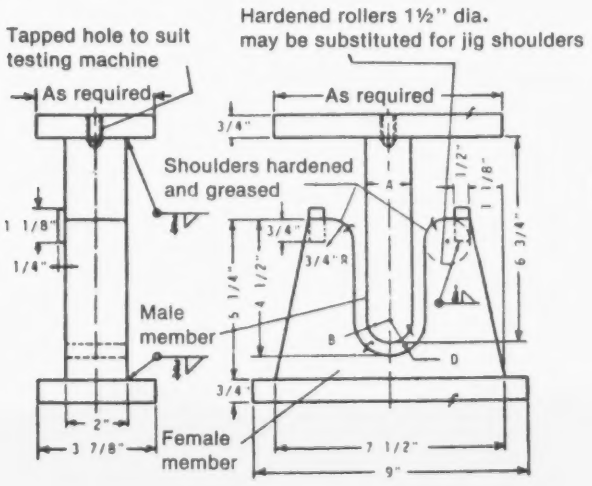
   NOTE: For a wraparound-type tester, a longer specimen probably be required.

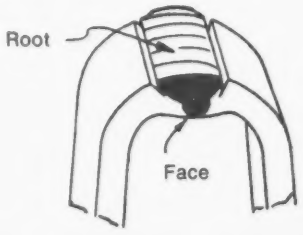


   b. Root bend specimen for a plunger-type tester should be a minimum 6" long, 1 1/2" wide and ground lengthwise so that both weld root and face are flush with the specimen surface.



6. Grind or file the corners of both specimens so they have a 1/8" radius. Take specimens to plunger-type tester and make bends as follows. _____





a. Place the face bend specimen on the die member of the jig with the weld face pointing into the die so that the plunger is on the weld's root side.

b. Actuate the plunger to force the specimen between the plunger and the die until it is formed into a U shape.

CAUTION: Always wear safety glasses when conducting bend tests.

c. Release pressure on plunger to release the specimen from the die.

7. Repeat testing procedure for the root bend, but reverse the weld root and face when placing on the die. — — — —

8. Inspect test specimens according to the following procedure. — — — —

a. Examine convex surface of both specimens for cracks or other open defects.

b. Check root bend to determine if weld has complete penetration through the joint.

c. Check face bend to determine if there is complete fusion of the beveled edges with the weld.

9. Ask instructor to check your bend test. — — — —

10. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competency E16.

MODULE: SHIELDED METAL ARC WELDING

UNIT VI: PLATE WELDING--FILLET AND GROOVES

UNIT OBJECTIVES

Upon completion of this unit, the student should be able to weld fillet and groove welds to specifications in various positions using one or more types of electrodes. This knowledge will be evidenced by completion of job sheets and the unit test to specified score.

SPECIFIC OBJECTIVES

1.1 Describe "F" and "G" abbreviations.

1.2 Identify welding numbering system notations (i.e. 1F, 2G, etc.).

1.3 Make fillet welds (laps and Ts) in various positions with E6010-6011, E7018 and E7024.

1.4 Make V-groove welds in various positions with E6010-6011, 7018 and 7024.

MODULE: SHIELDED METAL ARC WELDING

UNIT VI: PLATE WELDING--FILLET AND GROOVES

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: 3/8" PLATE WELDING

a. Information outline

b. Transparency masters

TM 1.1: Explanation of F positions
TM 1.2: Explanation of G positions

c. Job sheets

JS 1.1: Fillet weld in various positions
JS 1.2: Make V-groove welds in various positions

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Giachino, Joseph and William Weeks. Welding Skills and Practices. Chicago: American Technical Publishers, Inc., 1976.

2. Horwitz, Henry. Welding Principles and Practices. Boston: Houghton Mifflin Company, 1979.

3. Sacks, J. Raymond. Welding Principles and Practices. Peoria, Ill.: Charles A. Bennett Co., Inc., 1976.

B. Curriculum guide

1. Fortney, Clarence, and Mike Gregory. Shielded Metal Arc Welding. Stillwater, Okla.: Mid-America Vocational Curriculum Consortium, Inc., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. To supplement material in this unit, refer to a standard textbook for proper weld building and rod angles.

B. Suggested supplemental materials

1. Structural Welding Code--Steel (AWS code D1.1). Miami: American Welding Society, 1986.

2. Welding Heavy Plate (W-77-110). Sedalia, Mo.: The Media Center, State Fair Community College, 1977.

3. Single and Multiple Pass Fillet Welds (W-78-111). Sedalia, Mo.: The Media Center, State Fair Community College, 1978.

MODULE: SHIELDED METAL ARC WELDING

UNIT VI: PLATE WELDING--FILLET AND GROOVES

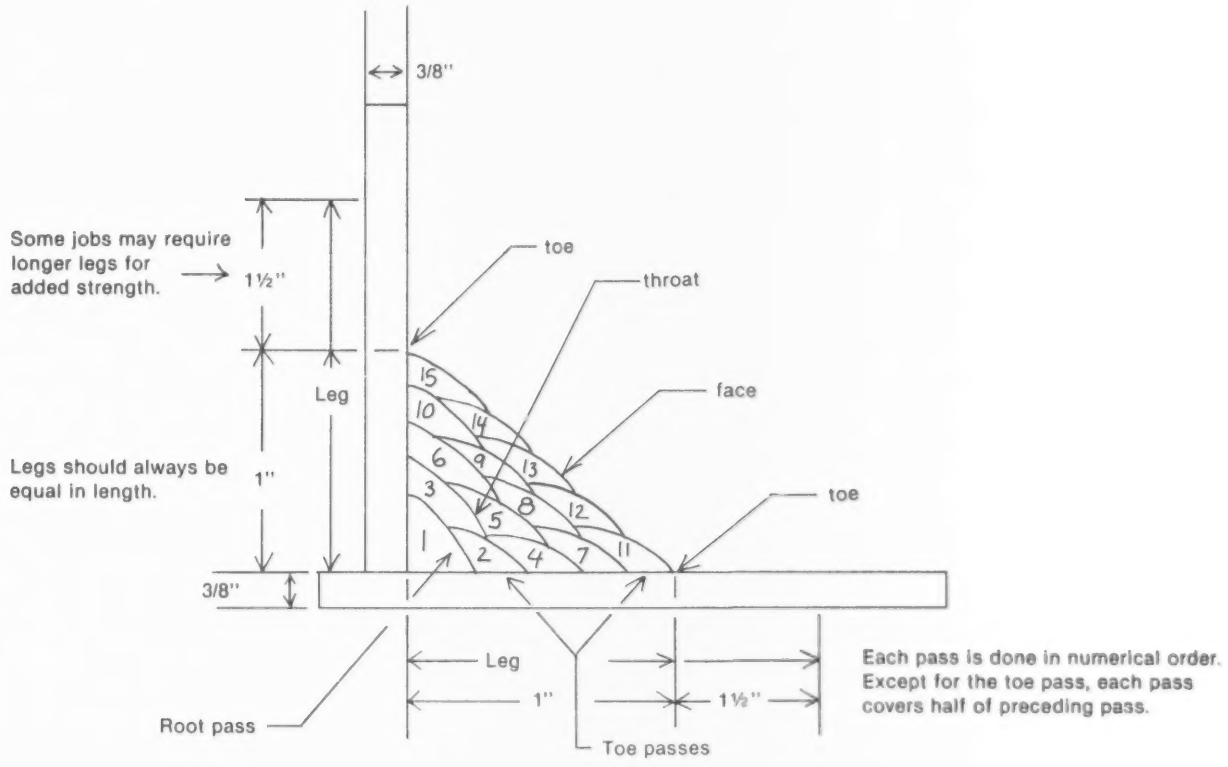
LESSON 1: 3/8" PLATE WELDING

I. F positions (TM 1.1)

A. F stands for fillet welds (any weld not requiring grooving). Examples: laps and Ts

B. F welds can be in all positions--flat, horizontal, vertical or overhead.

C. Regardless of the position, certain guidelines should be followed.



II. G positions (TM 1.2)

A. G stands for groove welds (any weld with a groove formed in it) Examples: T and butt welds

B. G welds can be in all positions--flat, horizontal, vertical or overhead.

III. Numbering system

A. 1 = Flat

B. 2 = Horizontal

C. 3 = Vertical (up or down)

D. 4 = Overhead

IV. Position of test welds (from AWS Structural Welding Code--Steel D1.1)

A. Weld classification (5.8.1)

1. All welds that will be encountered in actual construction shall be classified as flat, horizontal, vertical or overhead in accordance with the definition given in (AWS) fig 5.8.1.A. and 5.1.8. B.

2. Each procedure shall be tested in the manner stated below for each position for which it is to be qualified. Welding position limitations for procedure qualification are shown in Table 5.10.5.

NOTE: Refer to AWS Structural Welding Code for figures and tables.

B. Groove plate test welds (5.8.1.1). In making the tests to qualify groove welds, test plates shall be welded in the these positions.

1. Position 1G (flat). The test plates shall be placed in an approximate horizontal plane and the weld metal deposited from the upper side.

2. Position 2G (horizontal). The test plates shall be placed in an approximately vertical position with the groove approximately horizontal.

3. Position 3G (vertical). The test plates shall be placed in approximately vertical plane with the groove approximately vertical.

4. Position 4G (overhead). The test plates shall be placed in an approximately horizontal plane and the weld metal deposited from the underside.

C. Fillet welds (5.8.1.3)

1. Position 1F (flat). The test plates shall be so placed that each of the fillet welds is deposited with its axis approximately horizontal and its throat approximately vertical.

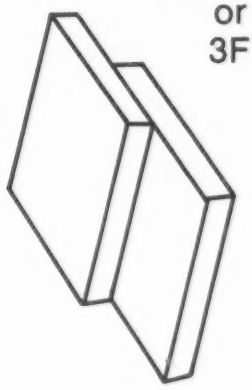
2. Position 2F (horizontal). The test plates shall be so placed that each fillet weld is deposited on the upper side of the horizontal surface and against the vertical surface.

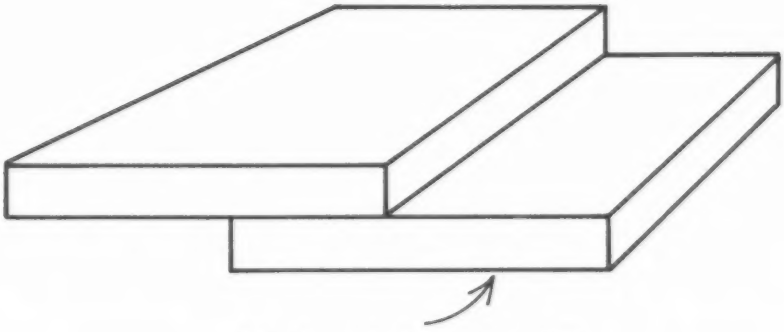
3. Position 3F (vertical). The test plates shall be placed in approximately vertical planes and each fillet weld deposited on the vertical surfaces.

4. Position 4F (overhead). The test plates shall be so placed that each fillet weld is deposited on the under side of the horizontal surface and against the vertical surface.

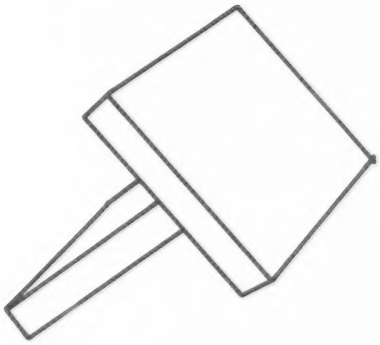
F WELDS AND POSITIONS

Vertical Lap
or
3F

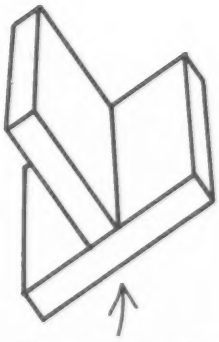




Horizontal Lap or 2F



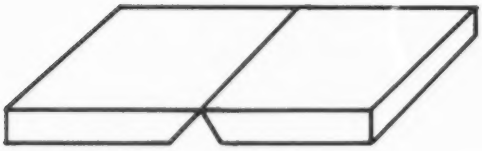
Overhead T or 4F



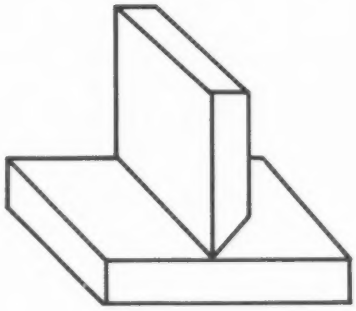
Flat T or 1F

Note: These positions will not require grooving unless more than 3/16" thick (T joints).

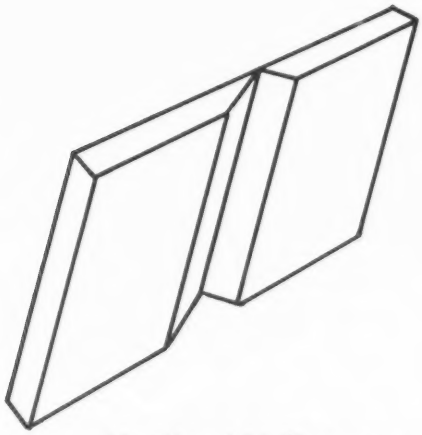
G WELDS AND POSITIONS



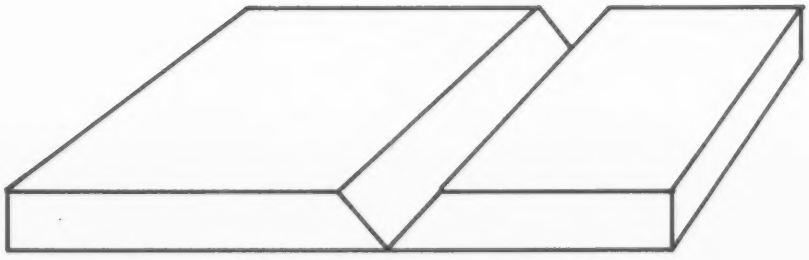
V Groove Overhead
or
4G



Horizontal Single Bevel T
or
2G



Vertical V Groove
or
3G



Flat V Groove or 1G

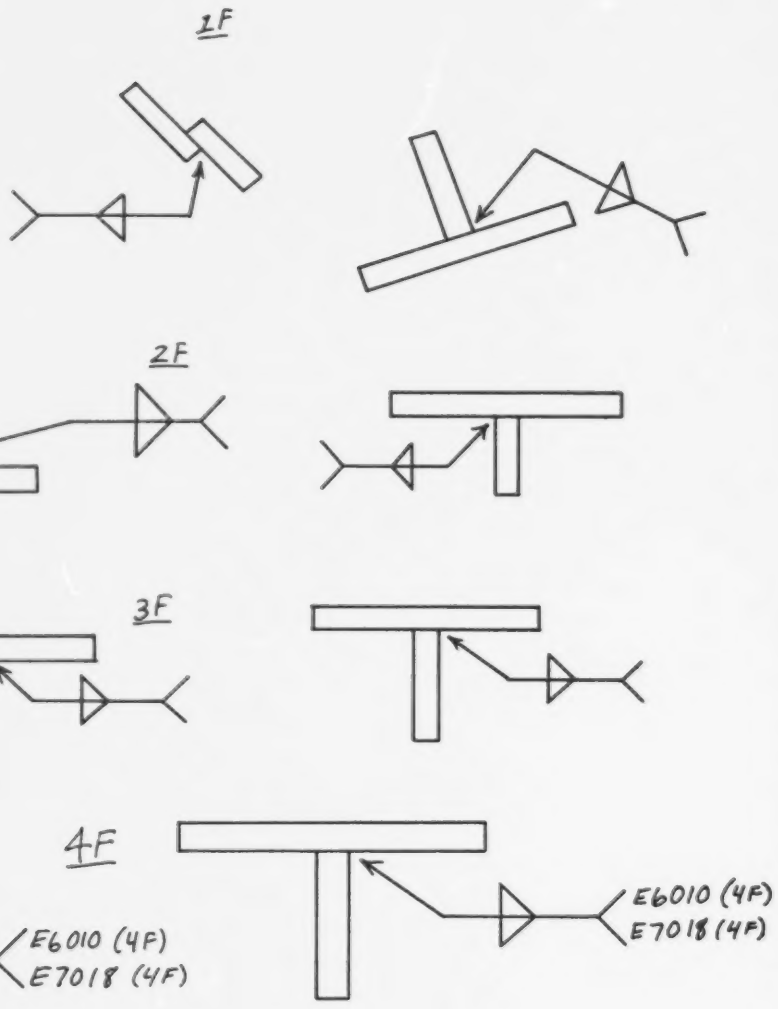
FILLET WELD IN VARIOUS POSITIONS

Equipment:

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
Mild steel plate, as selected by instructor
Safety glasses

Specifications:

Joint designs and weld symbols



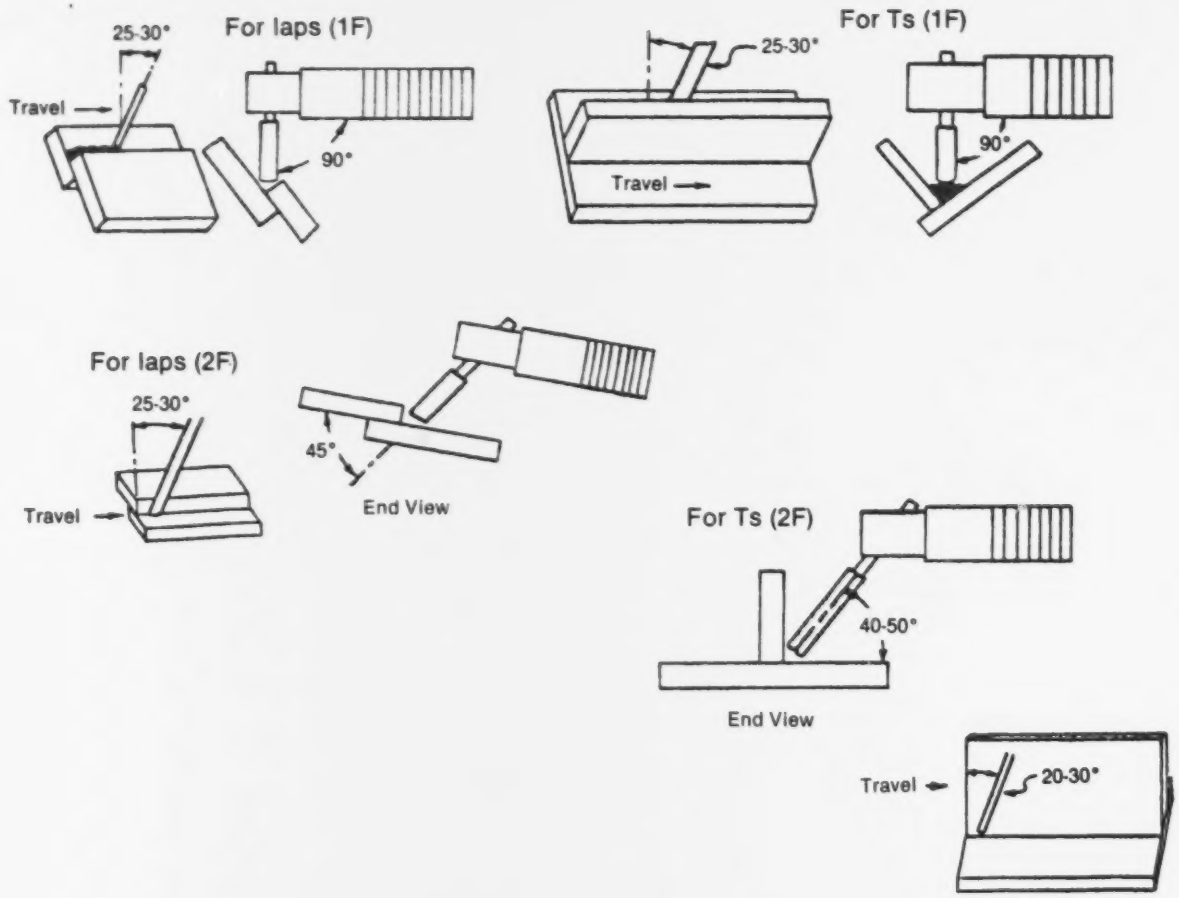
Filler metal and number of beads:
- E6010 or 6011, 1/8" or 5/32", single pass
- E7018, 1/8" or 5/32", single pass
- E7024, 1/8" or 5/32", three or more passes (flat position only)

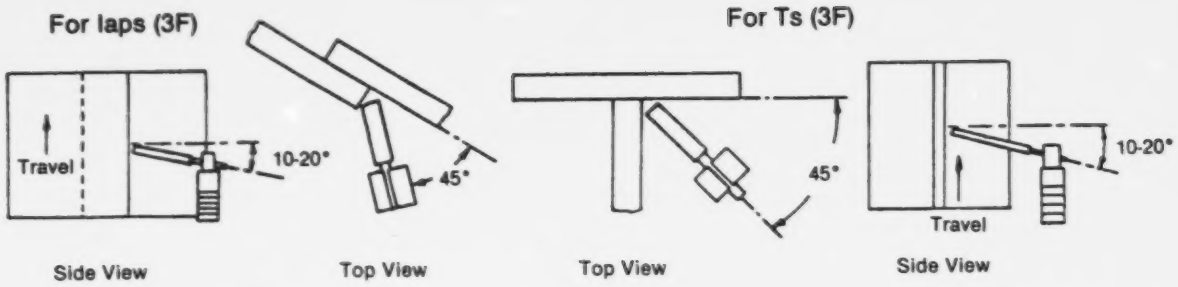
Positions: 1F, 2F, 3F, 4F
Direction of welding (3F): vertical up
Cleaning: chip and wire brush
Testing: visual
Technique: whipping for E6010 or 6011, drag for E7018 and E7024

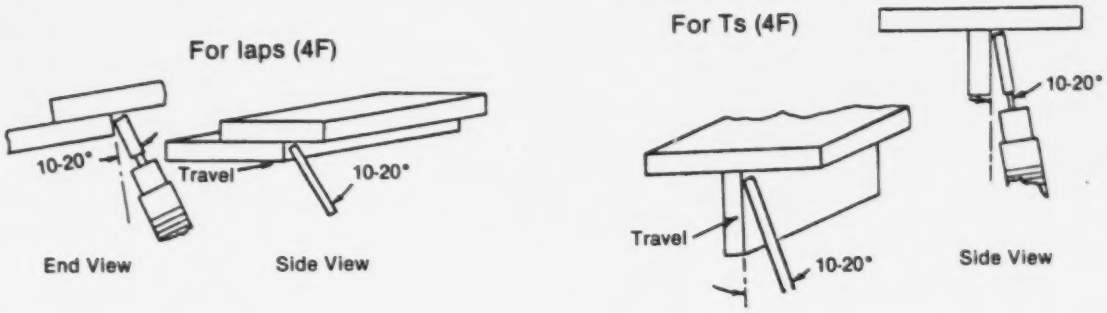
Procedure:

Evaluation
3 2 1 N

1. Attach ground clamp to table or workpiece. Select correct polarity for electrode. Turn on welding machine. — — — —
2. Adjust to correct amperage by running short beads on scrap material. — — — —
3. Prepare plates as required to form the joint and tack weld both ends of the joint. Place the joint so the weld will be in correct position. — — — —
4. Place electrode in holder as indicated. — — — —







5. Strike arc and adjust electrode to correct length. Adjust travel speed and electrode angle as required to make correct bead shape. — — — —

6. Weld the entire length of the joint and crater and backfill at the end of the joint. — — — —

7. Secure the workpiece with pliers and chip and brush the weld. Inspect weld visually for undercutting, too much spatter and uniform bead shape. — — — —

8. Ask inspector to check your work. — — — —

9. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competencies F1-F10.

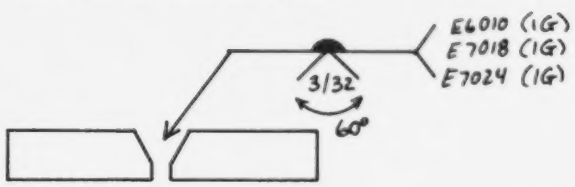
MAKE V-GROOVE WELDS IN VARIOUS POSITIONS

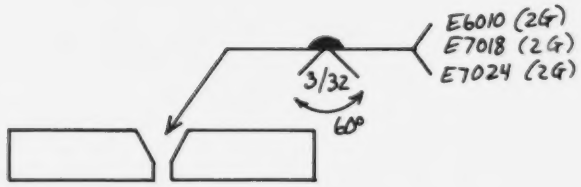
Equipment:

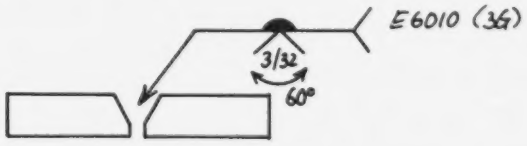
SMAW machine with accessories
Personal safety clothing, equipment and safety glasses
Pliers
Chipping hammer and wire brush
Portable hand grinder
Oxy-acetylene cutting unit
Soapstone
Straight edge
Cutting goggles
Sparklighter
File
Mild steel plates, as selected by instructor
3/32" gap wire
Bevel square

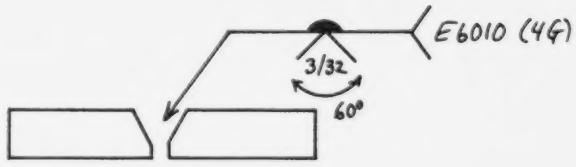
Specifications:

Joint design and weld symbol









Filler metal and number of beads:
- E6010, 1/8" or 5/32"
- E7018, 1/8" or 5/32"
- E7024, 1/8" or 5/32" (1G and 2G)

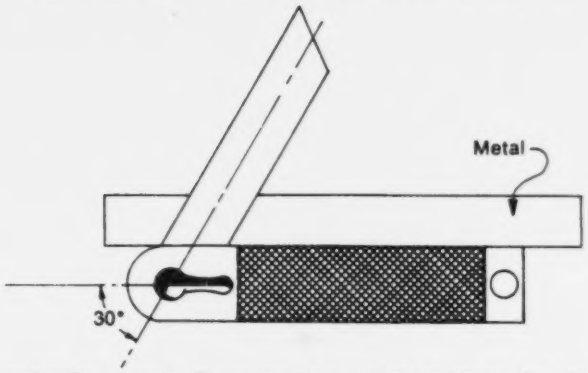
Positions: 1G, 2G, 3G, 4G
Direction of welding (3G): vertical up
Technique: whipping for E6010 or 6011, drag for 7018 and 7024
Cleaning: chip, wire brush, and grind
Testing: bend test on 3/8" plate

Procedure:

Evaluation
3 2 1 N

1. Check work area to make sure it is free of flammable materials and well ventilated. Note the location of the nearest fire extinguisher. — — — —

2. Place plates to be beveled on cutting table. Measure with the bevel square and mark the long side of the plate for a 37-degree bevel. — — — —



3. Light and adjust torch. Place torch at a right angle to the plate and tilt 37 degrees off the line to make the bevel cut on both plates. — — — —

NOTE: Beveling can be done with a machine torch as directed by your instructor. You may be advised to bevel several plates now to save time on future job sheet activities.

4. Turn off torch and secure system. Secure plates in one vise at a time. — — — —

5. Grind mill scale and slag from all surface areas to be welded. Be careful to retain a 37-degree bevel angle. Grind a 1/16" to 1/8" root face along the entire length of the bevel's thinnest part on all plates. — — — —

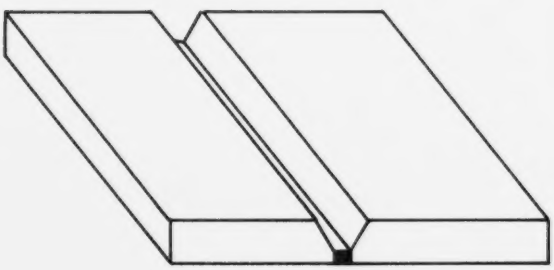
6. Attach ground clamp to work table or workpiece. Select correct polarity for electrode. — — — —

7. Turn on machine. Put on safety gear and adjust to correct amperage by running test beads on scrap metal. — — — —

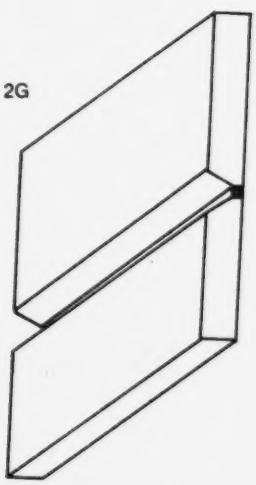
8. Align two plates face down on the work table, using a 3/32" gap wire to align and space them properly. Tack both ends of the joint and remove spacer wire. — — — —

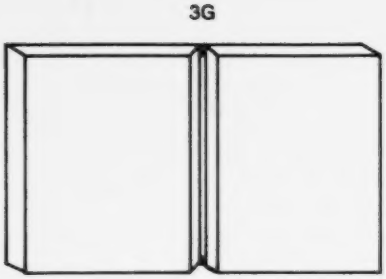
9. Position the plates so that the joint is in the position indicated in specifications. — — — —

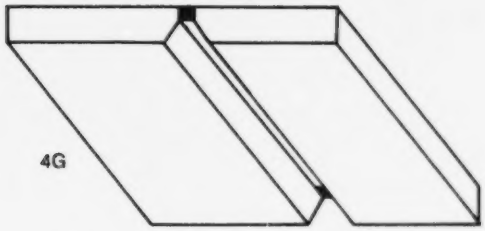
1G



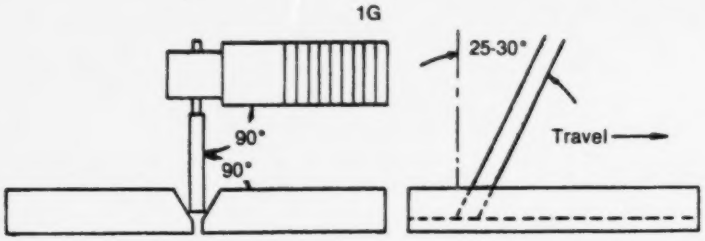
2G

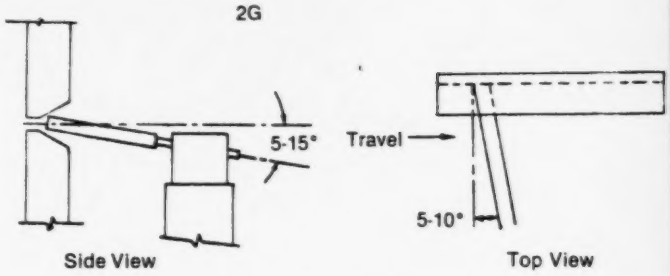


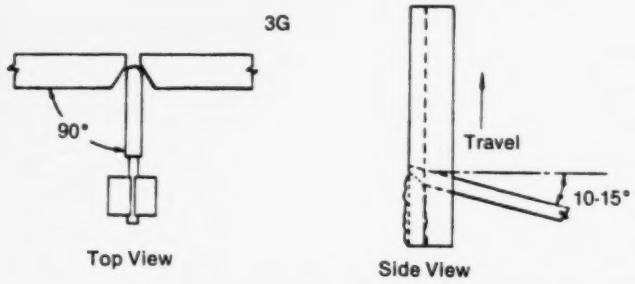


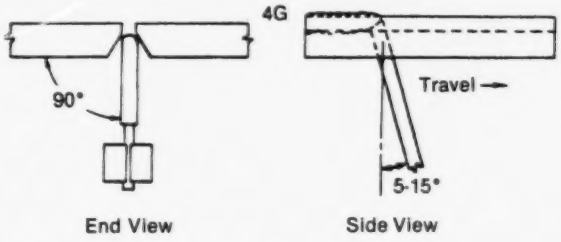


10. Place electrode in holder and adjust to correct electrode angle over the joint.



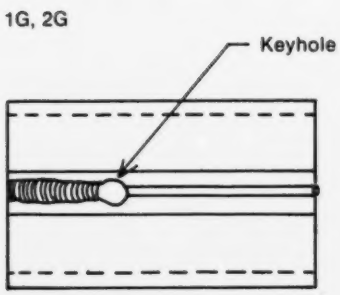


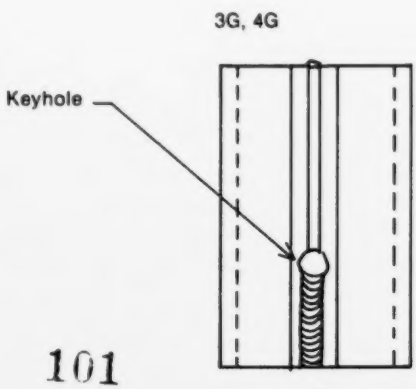




11. Strike arc and adjust electrode to correct arc length. Make a puddle and immediately allow the keyhole to form.

NOTE: When the keyhole is properly formed, it allows the filler metal to penetrate the joint completely.





12. Make a tie-in at any point where the electrode is used up with the following procedure. — — — —

    a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

    b. Grind the root pass with a portable grinder and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

    NOTE: Make other tie-ins with this same procedure.

13. Restrike the arc deep in the groove at a point no more than 1/4" from the keyhole. Hold a long arc to heat that portion of the pass. — — — —

14. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving. Repeat the procedure as required until the joint is completely welded. — — — —

15. Secure workpiece with pliers; clean and inspect root pass on both sides to make sure penetration is 100%. — — — —

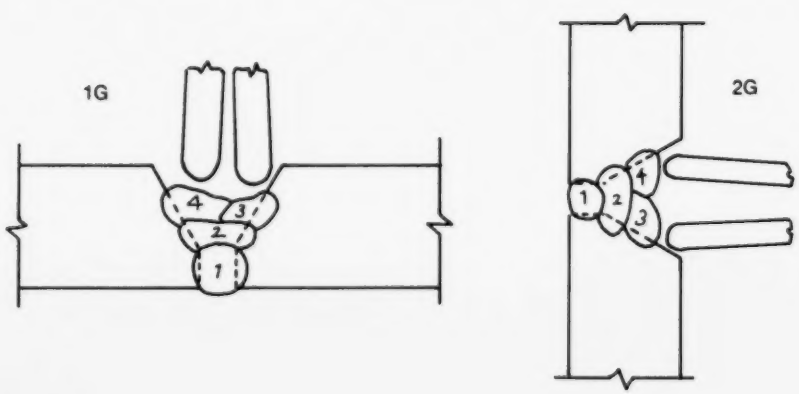
16. Grind the entire length of the root pass. — — — —

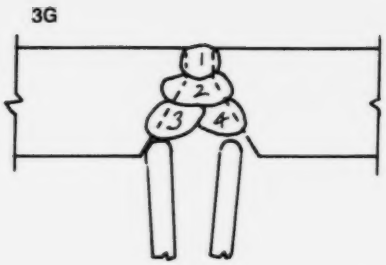
17. Increase amperage on welding machine about 15-20 amps. Use a whipping technique to run a hot pass over the entire length of the root pass, taking care not to blow a hole through the root pass. — — — —

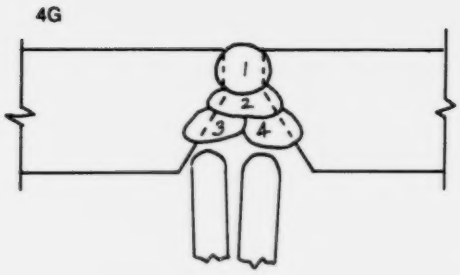
18. Secure workpiece with pliers; clean and inspect hot pass for good tie-in with the root pass. Grind the entire length of the hot pass, if required. — — — —

19. Adjust amperage to proper setting. Use correct technique to lay stringer beads for remainder of fill-up. Clean each stringer before starting next pass. — — — —

    NOTE: Numbers in the illustration indicate sequence, not quantity.

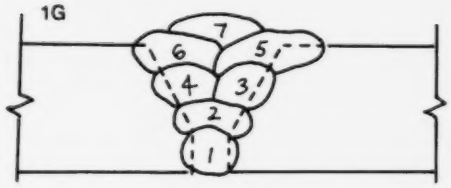


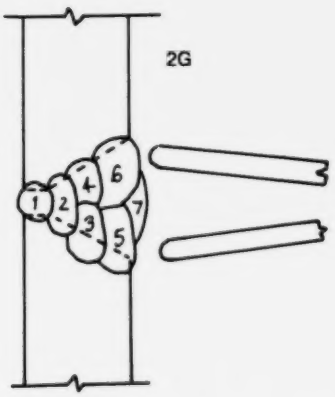


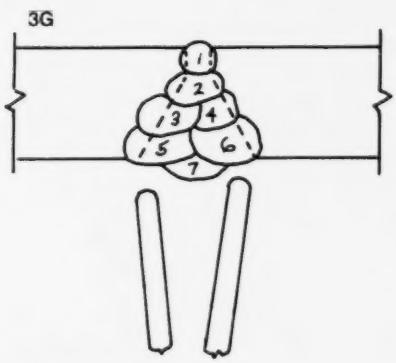


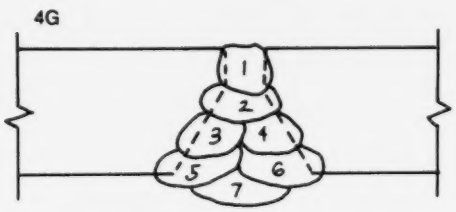
20. Clean fill-up stringer beads thoroughly to prepare for a cap pass. Use correct technique to lay stringer beads for the cap so that they have a convex shape from the toes to the face of the cap. _____

NOTE: The total height of the cap pass should be no thicker than a nickel. The sequence has to be followed carefully to accomplish this.









21. Clean and inspect cap pass. _____

22. Ask instructor to check your work. _____

23. Turn off the machine. Bend test as specified. _____

24. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. _____

Average of above evaluations* _____

*This average is the student's final evaluation for competencies F11-20.

MODULE: SHIELDED METAL ARC WELDING

UNIT VI: PLATE WELDING--FILLET AND GROOVES

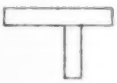
UNIT TEST

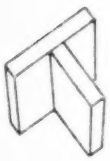
Identify the following joints by the number/letter system.

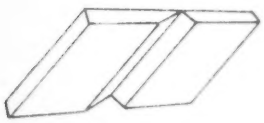
___ 1.

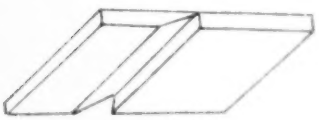
___ 2.

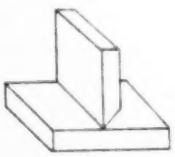
___ 3.

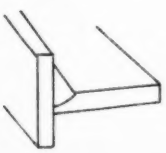
___ 4. 

___ 5. 

___ 6. 

___ 7. 

___ 8. 

___ 9. 

a. 1F

b. 2F

c. 3F

d. 4F

e. 1G

ab. 2G

ac. 3G

ad. 4G

___ 10.

Choose the option which best answers the question or completes the statement.

____ 11. Which of the following is true of the lettering system used for welds?

a. F stands for fillet welds.
b. Fillet welds are any welds not requiring grooving.
c. G stands for groove welds.
d. Groove welds are any welds with a groove formed in them.
e. All of the above

____ 12. Which of the following is <u>not</u> true?

a. F welds can be in flat, horizontal, vertical or overhead positions.
b. G welds can be in flat, horizontal or overhead positions only.
c. In the numbering system, 3 designates vertical positioning.
d. In the numbering system, 4 indicates overhead positioning.

____ 13. Some fillet welds may require _____ for added strength.

a. Longer legs
b. Legs of equal length
c. Shorter legs
d. Additional toe passes

____ 14. For a multi-pass fillet weld, each pass covers _____ of the preceding pass.

a. Only one-quarter
b. Half
c. Two-thirds
d. Three-quarters

ANSWERS TO UNIT TEST

1. ad (F19)
2. ab (F14)
3. b (F4)
4. d (F9)
5. ac (F17)
6. ad (F19)
7. ad (F20)
8. ab (F15)
9. e (F11)
10. e (F12)
11. e
12. b
13. a
14. b

MODULE: SHIELDED METAL ARC WELDING

UNIT VII: PIPE WELDING

UNIT OBJECTIVES

Upon completion of this unit, the student should be able to identify pipe welding positions, practice safety requirements for pipe welding and demonstrate the ability to weld pipe in various positions. This knowledge will be evidenced by achieving the specified score on the unit test and job sheets.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student will be able to:

1.1 Identify pipe welding in 1G-6G positions.

1.2 Demonstrate the ability to:

a. Bevel and prepare pipe for welding.

b. Bend test pipe weld.

c. Make welds in 1G and 2G positions.

d. Make welds in 5G and 6G positions.

MODULE: SHIELDED METAL ARC WELDING

UNIT VII: PIPE WELDING

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: PIPE WELDING

   a. Information outline

   b. Job sheets

      JS 1.1: Bevel and prepare pipe for welding
      JS 1.2: Conduct test of pipe weldment
      JS 1.3: Make pipe weld in 1G position
      JS 1.4: Make pipe weld in 2G position
      JS 1.5: Make pipe weld in 5G and 6G positions

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Giachino, Joseph, and William Weeks. Welding Skills and Practices. Chicago: American Technical Publishers, Inc., 1976.

2. Horwitz, Henry. Welding Principles and Practices. Boston: Houghton Mifflin Company, 1979.

3. Sacks, J. Raymond. Welding Principles and Practices. Peoria, Ill.: Charles A. Bennett Co., Inc., 1976.

B. Curriculum guides

1. Fortney, Clarence, and Mike Gregory. Shielded Metal Arc Welding. Stillwater, Okla.: Mid-America Vocational Curriculum Consortium, Inc., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested supplemental audiovisuals from The Media Center, State Fair Community College, Sedalia, Mo.

1. Introduction to Pipe Welding (W-78-140). 1978.

2. Pipe Welding Techniques (W-78-141). 1978.

3. Pipe Fittings and Basic Pipe Fittings (W-79-142). 1979.

MODULE: SHIELDED METAL ARC WELDING

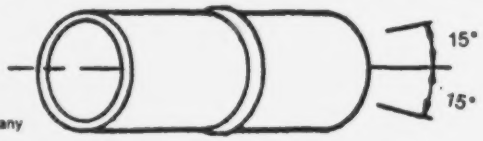
UNIT VII: PIPE WELDING

LESSON 1: PIPE WELDING

I. AWS test positions for groove welds on pipe

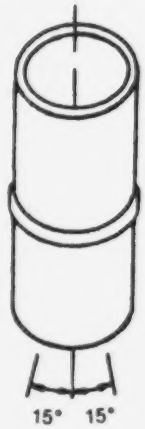
A. Flat position 1G: Pipe with its axis horizontal and rolled during welding so that weld metal is deposited from above.

NOTE: Angular deviations for horizontal and vertical planes may vary 15 degrees.



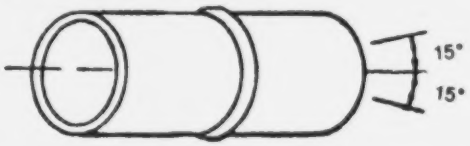
Courtesy Lincoln Electric Company

B. Horizontal position 2G: Pipe with its axis vertical and weld in a horizontal plane. Pipe is not rotated during welding.



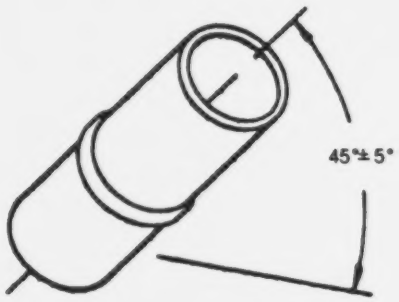
Courtesy Lincoln Electric Company

C. Multiple position 5G: Pipe with its axis horizontal and welding groove in a vertical plane. Pipe is not rotated during welding.



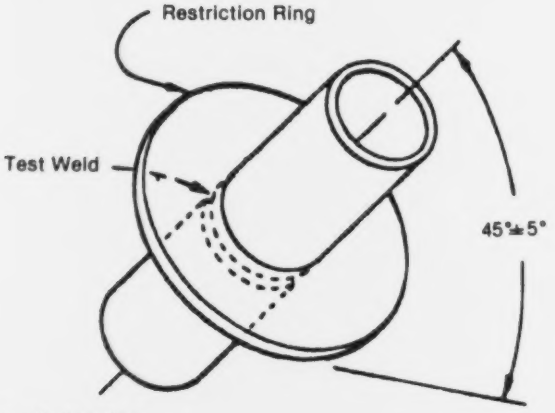
Courtesy Lincoln Electric Company

D. Multiple position 6G: Pipe with axis inclined at 45 degrees to horizontal. Pipe is not rotated during welding.



Courtesy Lincoln Electric Company

E. Position 6G for T, K and Y connections: Pipe with its axis inclined 45 degrees to horizontal. Pipe is not rotated during welding.



II. Joint preparation, fit-up and cleaning

A. General guidelines

1. Since joint preparation is critical to fit-up, bevels should be cut to required angles with all slag removed and bevels ground free of any imperfections.

2. Root faces or lands should be ground to the width specified with no irregular contours.

3. Fit-up should assure that pipes or fittings are properly aligned to common centering or reference points.

4. Since hammering is not recommended for fit-up or alignment, all errors resulting from poor preparation place an added burden on the welder, who must compensate for the problems with extra passes that take time and cost money.

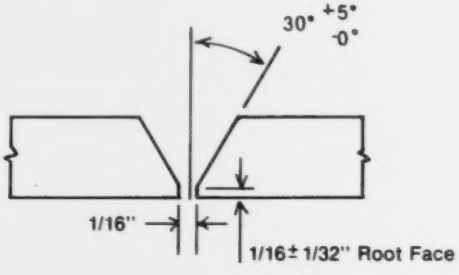
5. Poor pipe preparation and fit-up can easily result in piping systems that may not function. Properly preparing for pipe welding is as important as any part of the process.

B. Joint preparation

1. Standard joint design calls for a 30-degree bevel 5 degrees.

2. Root gap should be 1/16".

3. Root face or land should be 1/16" 1/32".



C. Cleaning requirements for all pipe welding

1. Every pass made in pipe welding should be thoroughly cleaned before the next pass is made. The cover pass should always be cleaned for inspection.

2. Grinding is the preferred method for cleaning pipe welds.

3. High spots along any pass should be ground down as cleaning takes place.

III. Techniques for pipe welding

A. Joint designs for horizontal pipe welding are the same as for vertical up and down.

B. Pass detail and sequence for horizontal pipe welding requires the following order.

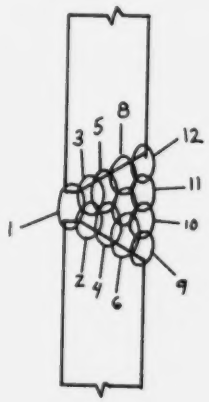
1. Lay the stringer bead with a slight whipping technique.

2. Place the first filler bead on the lower groove of the stringer bead so that it penetrates both the stringer bead and the lower pipe surface.

3. Place the following filler bead immediately above the first filler bead so that it penetrates the first filler bead and the upper pipe surface.

4. Start each filler pass on the lower side of the groove and build upward.

5. Build the cover pass from bottom to top.



IV. Beveling pipe

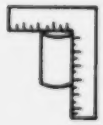
NOTE: If a pipe beveler is not available, the following methods can be used to bevel pipe for welding.

A. Flame cut and grind bevel

1. Use pipe wrap, a stiff piece of paper or cardboard to wrap the pipe and create a line around the pipe. Mark with soapstone.

2. Use a hand torch to cut the pipe along the marked line.

3. Secure pipe piece just cut in vise and use angle-head grinder. Grind pipe end to flat surface and check with square for trueness.



4. Use either pedestal or anglehead grinder to grind the desired angle to the pipe (15-30 degrees).

B. Saw and grind bevel

1. Use the same information above, but use a band saw to cut pipe instead of hand torch. Then grind as explained above.

BEVEL AND PREPARE PIPE FOR WELDING

Equipment:

Personal safety clothing and equipment
Oxy-acetylene cutting unit
Chipping hammer and wire brush
Portable grinder and cup brush
Cutting goggles and spark lighter
Steel pipe, 6" schedule 40
File
Pipe beveling machine
Soapstone marker
Wraparound
Jack stands
Retractable steel tape
Pliers
Bench vice
Safety glasses and face shield

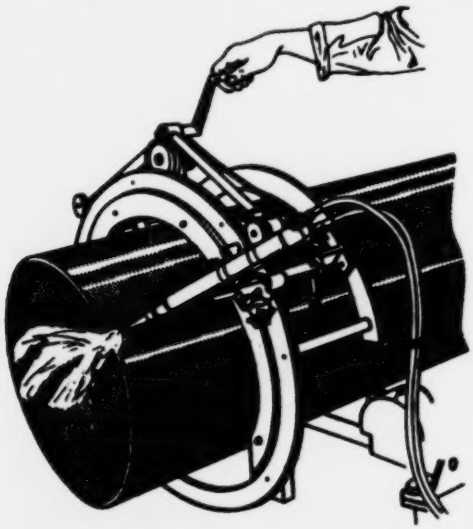
Procedure:

Evaluation
3 2 1 N

1. Check work area to make sure it is free of flammable materials and is well ventilated. Note the location of the nearest fire extinguisher. — — — —

2. Position pipe on jack stand so that about 3" of pipe extends out over the end jack stand to provide a comfortable working distance. Use the portable grinder with a cup brush to clean about 14" length of the pipe. — — — —

3. Clamp the pipe beveling machine onto the pipe so positioned that the torch tip at the end of the pipe can be adjusted to cut a 30-degree bevel. — — — —



4. Crank the pipe beveling machine all the way around the pipe for proper tracking so the torch tip stays an equal distance from the end of the pipe at all points on the circumference. — — — —

5. Position torch at top starting point. Set up oxy-acetylene cutting equipment in accordance with safety standards. Light and adjust torch to neutral flame, and pull down cutting goggles. — — — —

6. Check distance from end of inner cone to the surface of pipe, making sure it is 1/16" to 1/8". Preheat starting point until metal turns a dull red (1550 degrees). — — — —

7. Open the oxygen cutting valve to start cutting. Crank the beveling machine at a cutting speed that will give a good, clean cut. — — — —

8. Watch the cut and adjust cutting speed as required as you crank the beveling machine completely around the pipe to finish the cut. — — — —

9. Shut down oxy-acetylene torch. Inspect the bevel for a smooth, even cut. — — — —

10. Release beveling machine tension and move it back far enough on the pipe to provide comfortable space to use a wraparound. Clamp it onto the pipe again. — — — —

CAUTION: Hold onto the beveling machine as you move it to make sure it doesn't drop. Always hold the machine firmly when clamping it onto pipe or releasing tension.

11. Measure 6" back on the pipe from the outer edge of the bevel and mark. Place the wraparound around the pipe so that the wraparound makes a double lap and provides a reference to assure a true, straight line around the circumference. — — — —

12. Mark the circumference at the 6" point. Remove the wraparound and put it in a safe place. — — — —

13. Release beveling machine tension. Move it back so that the torch tip lines up with the cutting line just marked. Clamp the machine onto the pipe again. — — — —

14. Crank the beveling machine through a test run to make sure it is aligned with every point on the circumference. Adjust as needed. — — — —

15. Light and adjust to neutral flame and adjust inner cone so that it is 1/16"-1/8" from the surface of pipe. Move torch slowly around the cutting line to preheat the pipe. — — — —

16. Return to the top starting point. Open oxygen cutting valve. Crank beveling machine slowly around the pipe to finish the cut. — — — —

NOTE: Use pliers to hold the nipple as the cut is finished so the nipple will not fall on your foot.

17. Shut off torch. Inspect bevel for a smooth, even cut. — — — —

18. Ask instructor to check your work. — — — —

19. Repeat the procedure to cut the number of nipples directed by instructor. — — — —

20. Shut down oxy-acetylene equipment. Remove torch from beveling machine. Remove beveling from pipe and return it to proper storage area. — — — —

21. Secure nipples one by one in a bench vice so that axis of pipe is perpendicular to vise with the beveled end pointing up. Use a file to clean off any slag inside each nipple. — — — —

22. Use the portable grinder to grind 1/16" lands on all bevels or 3/32" lands on all bevels so that nipples to be welded together will have equal lands (helps avoid burn-through). — — — —

23. Ask instructor to check your work. — — — —

24. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

CONDUCT TEST OF PIPE WELDMENT

Equipment:

Bend test machine
Oxy-acetylene cutting unit
Personal safety clothing and equipment
Portable hand grinder
File
Pliers
Soapstone
Steel rule
Sparklighter
Cutting goggles
Groove-welded test pipe from previous job sheet
Safety glasses
Bench vise
Ball peen hammer
Hacksaw

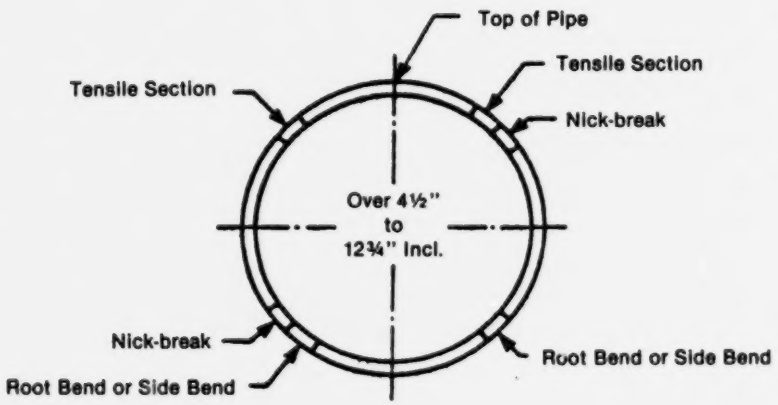
Procedure:

Evaluation 3 2 1 N

1. Check work area to make sure it is free of flammable materials and is well ventilated. Note the location of the nearest fire extinguisher. — — — —

2. Place test pipe on a work table in front of you and use the following procedure to mark and cut test specimens for top and bottom root bend, top and bottom face bend, and top and bottom nick-break tests. — — — —

   a. Determine a top starting point to work from and cut test specimens from each quarter indicated.



b. Mark all test specimens so that they intersect the weld perpendicularly and are 1 1/2" wide. Cut specimens the full length of the pipe.

c. Cut off excess pipe so that each specimen is 9" long with the weld centered.

d. Label specimens according to location as TR for top root, TF for top face, BR for bottom root, BF for bottom face, TN for top nick-break, and BN for bottom nick-break.

e. Allow specimens to air cool. Do not quench them in water.

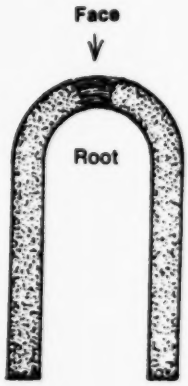
3. Secure individual cooled bend test specimens, one at at time, in a vise. Grind off slag on cutting edges and grind welds so that the root and face of each weld is flush with the pipe's surface. _____

CAUTION: Do not grind beneath the surface of the base metal or the specimen will be useless. Do all grinding so that it is perpendicular to the weld.

4. Ask instructor to check your test specimens. _____

5. Take specimens to plunger-type bend tester and make bend tests according to the following procedure. _____

a. Place a face bend specimen on the die member of the jig with the face of the weld pointing into the die. The plunger will be on the root side of the weld.



b. Start the plunger to force the specimen between the plunger and the die until it is formed into a U shape.

c. Release the plunger. Remove the specimen and repeat the procedure for the other face bend specimen.

d. Place a root bend specimen on the die member of the jig with the root of the weld pointing into the die. The plunger will be on the face side of the weld.

e. Start the plunger to force the specimen between the plunger and the die until it is formed into a U shape.

f. Release the plunger. Remove the specimen and repeat the procedure for the other root bend specimen.

6. Inspect test specimens according to the following procedure. — — — —

a. Examine convex surface of both specimens for cracks or other defects.

b. Check root bends to determine if welds have complete penetration through the joint.

c. Check face bends to determine if there is complete fusion of the beveled edges with the welds.

7. Ask instructor to check your bend tests. — — — —

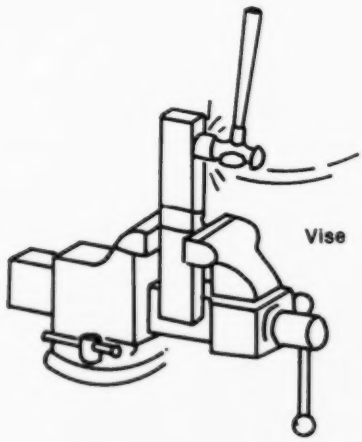
8. Take cooled nick-break test specimens one at a time. Secure each in a vise. Cut and grind so that each specimen is 9" long and 1" wide with no weld reinforcement removed from either side of specimen. — — — —

9. With a hacksaw, cut a centered groove 1/8" deep on each side of the weld reinforcement. Use a file or grinder to make edges smooth and parallel. — — — —

10. Ask instructor to check nick-break test specimens. — — — —

11. Secure one nick-break specimen in a bench vise firmly perpendicular to the vise with the bottom edge of the weld positioned just above the jaws of the vise. — — — —

12. Strike the test specimen from one side with a ball peen hammer hard enough to break it with a single blow. Put the other test specimen in the vise and repeat the procedure. — — — —



13. Check each nick-break test specimen for the following. _ _ _ _

    a. Complete penetration and fusion

    b. Gas pockets that exceed 1/16" or combined gas pockets covering more than 2% of the exposed surface area

    c. Slag inclusions that are more than 1/8" long or longer than one-half the nominal wall thickness of the pipe

    d. At least 1/2" solid weld metal between any slag inclusions.

14. Ask your instructor to check your nick-break test specimens. _ _ _ _

15. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. _ _ _ _

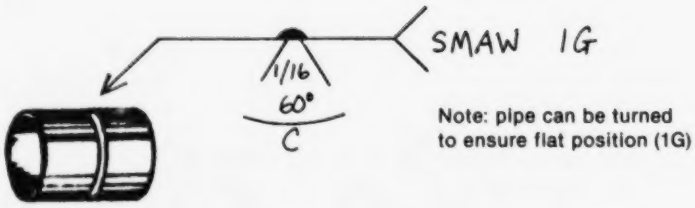
MAKE PIPE WELD IN 1G POSITION

Equipment:

SMAW machine with accessories
Personal safety clothing and equipment
Chipping hammer and wire brush
Pliers
Portable grinder with wire brush
Straight edge
1/16" gap wire
6" schedule 40 pipe nipples
Electrodes as specified
Safety glasses

Specifications:

Joint design and weld symbol

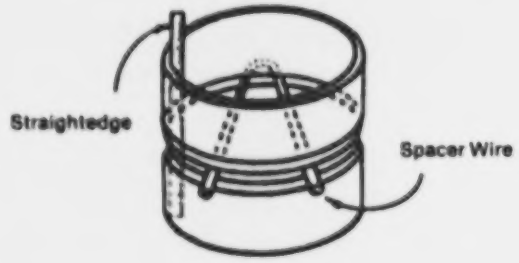


Note: pipe can be turned to ensure flat position (1G)

Electrode: 3/32", 1/8", 5/32"
E6010 or 6011, E7018, E7024 (maximum of three passes)
Electrical: DC+
Position: 1G
Technique: drag and/or whip
Cleaning: grind and brush
Testing: bend

Procedure:	Evaluation 3 2 1 N
1. Check work area to make sure it is free of flammable materials and is well ventilated. Note the location of the nearest fire extinguisher.	— — — —
2. Attach ground cable to work table or workpiece. Select correct polarity for electrode. Turn on SMAW machine.	— — — —
3. Put on welding helmet and adjust machine to correct amperage by running a test bead on scrap metal.	— — — —
4. Place two 6" nipples on work table positioned so that one is on top of the other to form a vertical axis with a 1/16" gap wire placed between the two.	— — — —

5. Place a straight edge along the inside of the nipples and align them vertically. — — — —



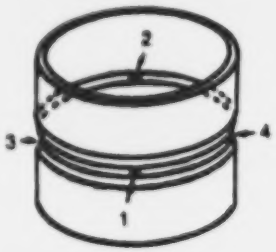
6. Tack weld the members in place. — — — —

   a. Start between the spread ends of the gap wire and make the first tack weld.

   b. Move 180 degrees opposite the first tack weld. Pull the gap wire out from between the two nipples. Use one end of the gap wire to recheck the gap at that point. Make second tack weld.

   c. Move 90 degrees in either direction from the second tack weld and make the third tack weld.

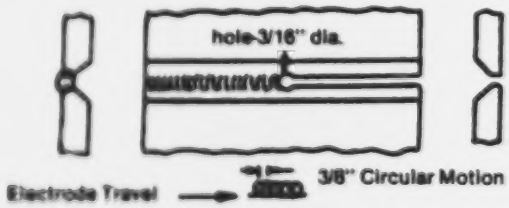
   d. Move 180 degrees opposite the third tack weld and make the fourth.



7. Feather all tack welds with a grinder, being careful not to grind through the tack weld. Place the nipples in the position indicated in specifications. — — — —

8. Place electrode in electrode holder and adjust to correct electrode angle. — — — —

9. Strike an arc on one of the feathered tacks and quickly adjust to proper arc length. Make a puddle and immediately form a keyhole. — — — —



10. Whip the rod slightly forward to allow the keyhole to solidify; then whip the rod back to deposit more metal in the keyhole. — — — —

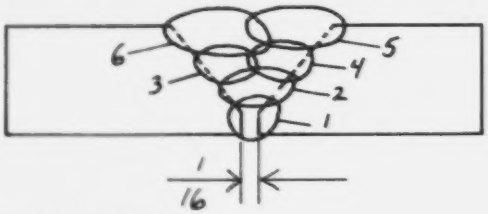
11. Chip slag off stringer bead. Brush it, then grind the entire bead with a hand grinder. Inspect root pass for good fusion and penetration and for defects such as undercutting on both outside and inside surfaces. — — — —

12. Increase machine amperage setting by 15-20 amps. Using the same electrode, run a hot pass with a whipping technique over the entire stringer bead. Take care not to burn through the stringer. — — — —

13. Chip slag off hot pass. Brush it and grind off any high spots. — — — —

14. Decrease amperage to proper setting for electrode. Using the same electrode and a whipping technique, lay stringer beads for remainder of fill-up. Be sure to clean each pass before starting another. — — — —

NOTE: The numbers below indicate sequence, not quantity.



15. Clean fill-up stringer beads thoroughly. — — — —

16. Ask instructor to check your work. — — — —

17. Shut down SMAW equipment. Conduct a bend test as outlined in the previous job sheet. — — — —

18. Ask instructor to check your bend test. — — — —

19. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competencies G1-G3.

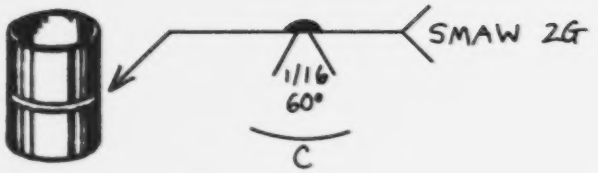
MAKE PIPE WELD IN 2G POSITION

Equipment:

SMAW machine with accessories
Personal safety clothing and equipment
Chipping hammer and wire brush
Pliers
Portable grinder with wire brush
Straight edge
1/16" gap wire
6" schedule 40 pipe nipples
Electrodes as specified
Safety glasses

Specifications:

Joint design and weld symbol

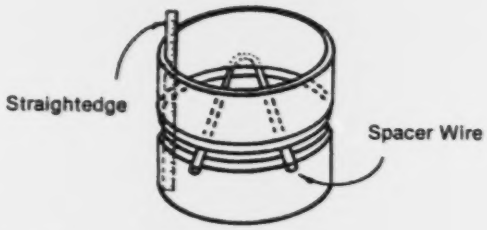


Electrode: 3/32", 1/8", 5/32"
E6010, E7018, E7024 (maximum of three passes)
Electrical: DC+
Position: 2G
Technique: drag and/or whip
Cleaning: grind and brush
Testing: bend

Procedure:

		Evaluation 3 2 1 N
1.	Check work area to make sure it is free of flammable materials and is well ventilated. Note the location of the nearest fire extinguisher.	— — — —
2.	Attach ground cable to work table or workpiece. Select correct polarity for electrode.	— — — —
3.	Turn on SMAW machine. Put on welding helmet and adjust machine to correct amperage by running a test bead on scrap metal.	— — — —
4.	Place two 6" nipples on work table positioned so that one is on top of the other to form a vertical axis with a 1/16" gap wire placed between the two.	— — — —

5. Place a straight edge along the insides of the nipples and align them vertically. — — — —



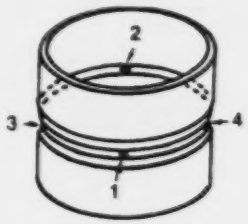
6. Tack weld the members in place. — — — —

   a. Start between the spread ends of the gap wire and make the first tack weld.

   b. Move 180 degrees opposite the first tack weld. Pull out the gap wire from between the nipples. Use one end of the gap wire to recheck the gap at that point. Make the second tack weld.

   c. Move 90 degrees in either direction from the second tack weld and make the third tack weld.

   d. Move 180 degrees opposite the third tack weld and make the fourth tack weld.

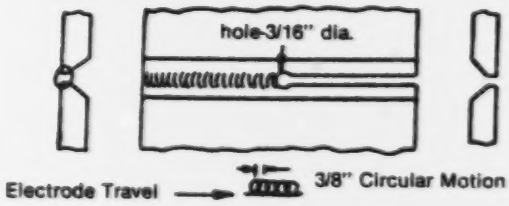


7. Feather all tack welds with a grinder, but be careful not to grind all the way through the tack weld. Place the nipples so that they are in the position indicated in specifications. — — — —

8. Place electrode in electrode holder and adjust to correct angle. Strike an arc on one of the feathered tacks and quickly adjust to proper arc length. — — — —

   CAUTION: Strike the arc only in the weld zone and not on the finished sides of the pipe.

9. Make a puddle and immediately form a keyhole. — — — —



10. Whip the rod slightly forward to allow the keyhole to solidify; then whip the rod back to deposit more metal in the keyhole. — — — —

NOTE: Do not deposit filler metal outside the keyhole as you whip the rod back and forth. Always move the rod back to the center of the keyhole, and keep electrode arcing in the middle of the joint, not on the outer portion of the bevel.

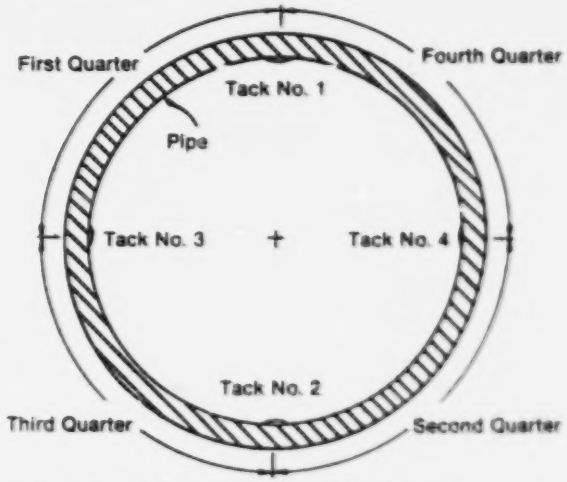
11. Weld to the center of the next tack weld. Stop, then use quartering to control heat and distortion as you finish the stringer. — — — —

12. At 90 degrees around the pipe from your point, strike an arc at the tack weld. Weld to the center of the next tack weld. — — — —

13. At 180 degrees around the pipe from your second stopping point, strike an arc at the tack weld there, and weld to the center of the next tack weld. Stop where the previous bead started. — — — —

14. At 90 degrees around the pipe from your third stopping point, strike an arc where the previous bead ended on the tack weld there. Weld to the center of the next tack weld and stop where the previous bead started. — — — —

NOTE: The quartering procedure just completed will not require cleaning if you're careful to stop each quarter stringer at a tack weld center.



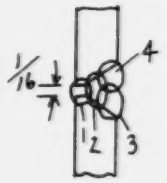
15. Chip slag off stringer bead and brush it or grind the entire stringer bead with a hand grinder. — — — —

16. Inspect the root pass for good fusion and penetration and for defects such as undercutting on both outside and inside surfaces. — — — —

17. Increase machine amperage setting by 15-20 amps. Using the same electrode and a whipping technique, run a hot pass over the entire stringer bead. Take care not to burn through the stringer. — — — —

18. Chip slag off hot pass. Brush it and grind off any high spots. — — — —

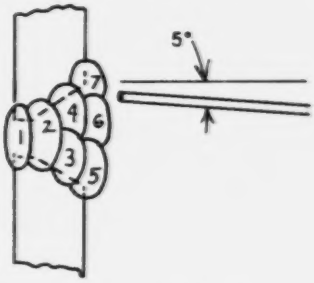
19. Decrease amperage to proper setting for electrode. Use the same electrode, and with a whipping technique, lay stringer beads for remainder of fill-up. Be sure to clean each pass before starting another one. — — — —



NOTE: The numbers in this illustration indicate sequence, not quantity.

20. Clean fill-up stringer beads thoroughly. — — — —

21. Using the same electrode and a whipping technique, lay cap pass to finish weld. Clean and inspect cap pass. — — — —



22. Ask instructor to check your work. — — — —

23. Shut down SMAW equipment. Conduct a bend test as outlined in the previous job sheet. — — — —

24. Ask instructor to check bend test. — — — —

25. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competencies G4-G6.

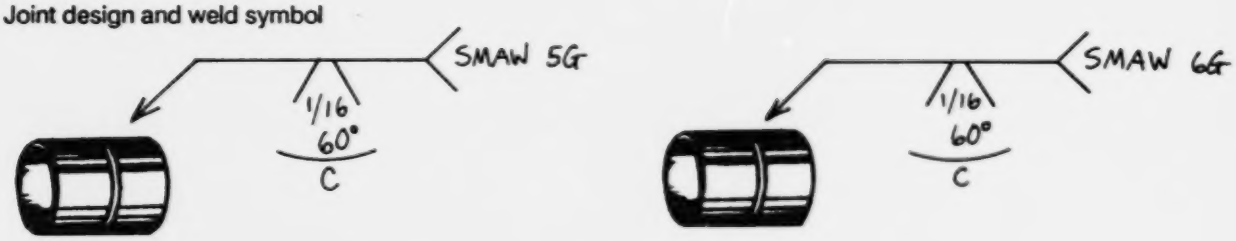
MAKE PIPE WELD IN 5G AND 6G POSITIONS

Equipment:

SMAW machine with accessories
Personal safety clothing and equipment
Chipping hammer and wire brush
Pliers
Portable grinder with wire brush
Straight edge
1/16" gap wire
6" schedule 40 pipe nipples
Electrodes as specified
Safety glasses

Specifications:

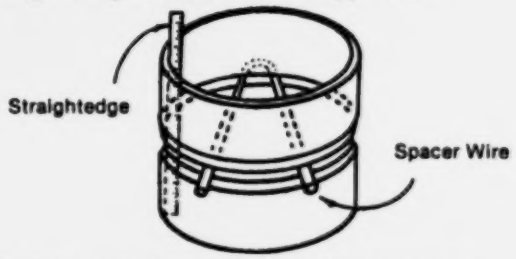
Joint design and weld symbol



Electrode: EXX10, root pass; EXX18, filler and cap 3/32", 1/8" or 5/32"
E6010 or 6011 and E7018 for 6G
Electrical: DC+
Positions: 5G and 6G
Technique: drag and/or whip
Cleaning: grind and brush
Testing: bend

Procedure:	Evaluation 3 2 1 N
1. Check work area to make sure it is free of flammable materials and is well ventilated. Note the location of the nearest fire extinguisher.	— — — —
2. Attach ground cable to work table or workpiece. Select correct polarity for electrode.	— — — —
3. Turn on SMAW machine. Put on welding helmet and adjust machine to correct amperage by running a test bead on scrap metal.	— — — —

4. Place two 6" nipples on work table positioned so that one is on top of the other to form a vertical axis with a 1/16" gap wire placed between the two. Place a straight edge along the insides of the nipples and align them vertically.



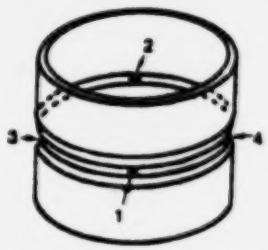
5. Tack weld the members in place according to the following procedure.

   a. Start between the spread ends of the gap wire and make the first tack weld.

   b. Move 180 degrees opposite the first tack weld. Pull the gap wire out from between the two nipples. Use one end of the gap wire to recheck the gap at that point. Make second tack weld.

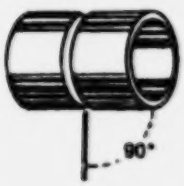
   c. Move 90 degrees in either direction from the second tack weld and make the third tack weld.

   d. Move 180 degrees opposite the third tack weld and make the fourth.

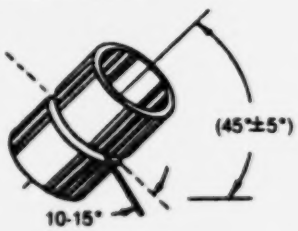


6. Feather all tack welds with a grinder, but be careful not to grind all the way through the tack weld. Place nipples so that they are in the position indicated by specifications.

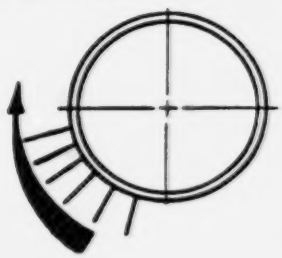
7. Place electrode in electrode holder and adjust to correct electrode angle.



5G



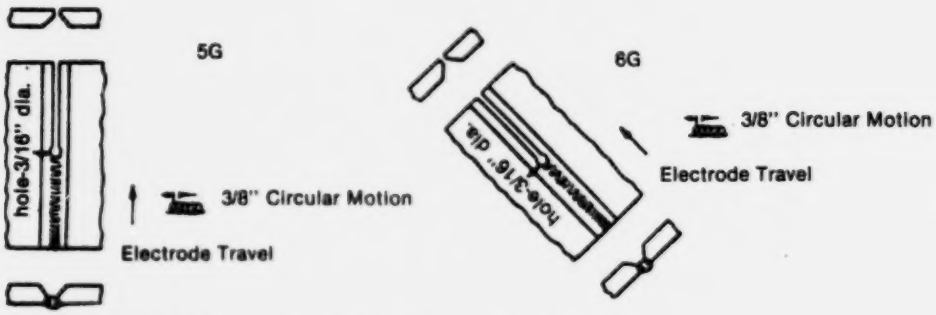
6G



8. Strike an arc on one of the feathered tacks at 3:00 (or 9:00) and quickly adjust to proper arc length.

   CAUTION: Strike the arc only in the weld zone and not on the finished sides of the pipe.

9. Make a puddle and immediately form a keyhole. — — — —



10. Whip the rod slightly forward to allow the keyhole to solidify; then whip the rod back to deposit more metal in the keyhole. — — — —

NOTE: Do not deposit filler metal outside the keyhole as you whip the rod back and forth. Always move the rod back to the center of the keyhole. Keep electrode arcing in the middle of the joint, not on the outer portion of the bevel.

11. Weld to the center of the 12:00 tack weld. Stop, then use quartering to control heat and distortion as you finish the stringer. — — — —

12. Restart arc at center of tack weld at 6:00. Form proper keyhole, and weld to the center of the tack weld at 9:00. — — — —

13. Go back to the tack weld at 6:00. Restart arc to tie-in with previous quarter pass. Form proper keyhole and weld up to tack weld at 3:00, tying in with first quarter pass. — — — —

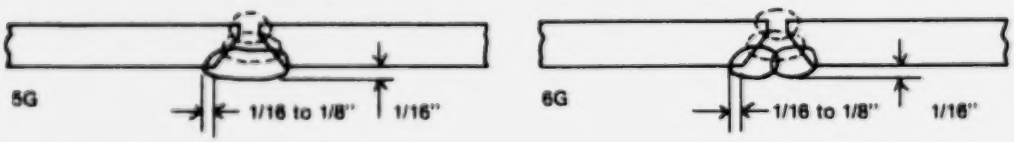
14. Go across to tack weld at 9:00. Restart arc to tie in with previous quarter pass. Form proper keyhole and weld up to tack weld at 12:00, tying in with the first quarter pass. — — — —

15. Chip slag off stringer bead and brush it or grind the entire stringer bead with a hand grinder. Inspect the root pass for good fusion and penetration, and for defects such as undercutting on both outside and inside surfaces. — — — —

16. Adjust amperage to proper setting for electrode. With a weaving technique, lay stringer beads for remainder of fill-up. Be sure to clean each pass before starting the next one. — — — —

17. Clean fill-up stringer beads thoroughly. — — — —

18. Using the electrode and a weaving technique, lay a cap pass to finish the weld in vertical up welding from 6:00 to 12:00 on each side. — — — —



20. Clean and inspect cap pass. — — — —

SMAW 163

21. Ask instructor to check your work. — — — —

22. Shut down SMAW equipment. Conduct a bend test as outlined in the previous job sheet. — — — —

23. Ask instructor to check your bend test. — — — —

24. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

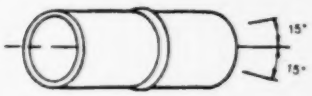
*This average is the student's final evaluation for competency G7-G10.

MODULE: SHIELDED METAL ARC WELDING

UNIT VII: PIPE WELDING

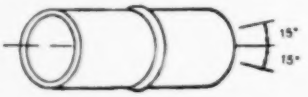
UNIT TEST

Identify the following AWS test positions for groove welds on pipe by choosing the letter of the position definition.

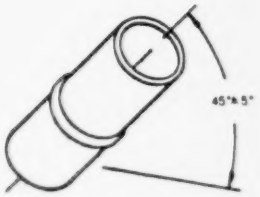


1 _____

2 _____



3 _____



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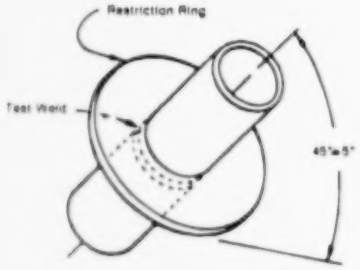


5 _____

a. Position 6G for T, K and Y connections

b. Multiple position 6G

c. Horizontal position 2G

d. Flat position 1G

e. Multiple position 5G

ANSWERS TO UNIT TEST

1. d
2. c
3. e
4. b
5. a

MODULE: SHIELDED METAL ARC WELDING

UNIT VIII: 16-GAUGE STEEL

UNIT OBJECTIVES

Upon completion of this unit, the student should be able to discuss specific techniques used when welding 16-gauge steel with SMAW. The student should demonstrate the ability to make fillet and butt welds on 16-gauge steel in various positions. This knowledge will be evidenced by completion of job sheets to specified score.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Use information presented on material thickness and amperage, electrode size, arc length, fit-up and polarity changes to demonstrate the ability to:

a. Make fillet welds in various positions using 16-gauge steel.*

b. Make square butt welds in various positions, using 16-gauge steel.*

*Addresses competency on profile

MODULE: SHIELDED METAL ARC WELDING

UNIT VIII: 16-GAUGE STEEL

CONTENTS OF THIS UNIT

A. Objective sheet

B. Notes to the instructor

C. Lesson plans

1. Lesson 1: TECHNIQUES

a. Information outline

b. Job sheets

JS 1.1: Make fillet welds in various positions using 16-ga. steel
JS 1.2: Make square butt welds in various positions using 16-ga. steel

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Missouri's welding competency list requires that students become competent in welding 16-gauge (or the closest material to that thickness) in a variety of joints and positions. If using a gauge of steel other than 16 (such as 12 or 14), modify procedures accordingly.

2. The cognitive and psychomotor skills have already been covered in the preceding sections on SMAW. This unit (and the corresponding competencies) have been prepared so that students will be exposed to light-gauge SMAW welding.

3. Rather than repeat all previous, applicable lesson plans and job sheets, only a few pointers in welding light-gauge material have been given in the information sheets.

B. Suggested student activities

1. Have students weld up sheet metal boxes and air test for leaks in preparation for when they make non-leak oil tanks, gas tanks and chemical tanks. Regulators should be used when testing tanks with air so the tank will not be damaged.

MODULE: SHIELDED METAL ARC WELDING

UNIT VIII: 16-GAUGE STEEL

LESSON 1: TECHNIQUES

I. Material thickness and amperage

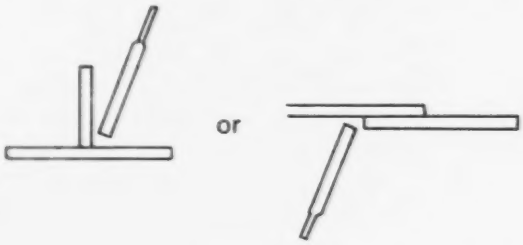
NOTE: When welding thin materials, use the downhand position to prevent burn-through (3G-90).

A. Lower the amperage for welding 16-ga. steel.

B. Using a larger electrode, the welder can use a lower amperage setting to reduce arc blow and help eliminate burn-through. (Unfortunate side effects are slag inclusion, poor fusion and lack of penetration.)

C. Since the edges of thin material more apt to melt or burn away, try to change rod angle (in lap and T joints) to apply the majority of the electrode heat to the piece with a larger heat sink.

Example:



II. Electrode size

A. A smaller electrode, such as one 3/32" in diameter, makes it easier to hold burn-through to a minimum.

B. Smaller electrodes are more difficult to use. It takes a skilled technique to use a 3/32" or 1/16" electrode.

III. Arc length

A. Arc length is proportional to voltage in SMAW.

B. The larger the arc length, the higher the voltage. The shorter the arc length, the lower the voltage.

C. Hold electrodes to a tight arc.

IV. Fit-up of materials

A. Any gap or poor fit can mean more heat-through of a joint and possible burn-through.

B. Make sure joints fit tightly and butt together flat in good alignment. Because of warping problems, tack metal often and closely together.

V. Polarity changes

A. When welding light-gauge metal, the depth of penetration is much less critical. (Fusion is still wanted, but excessive penetration is not needed.)

B. A change from one polarity to another can reduce burn-through or excessive arc force.

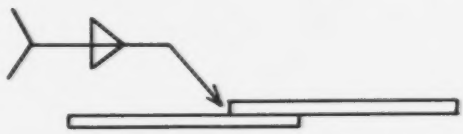
MAKE FILLET WELDS IN VARIOUS POSITIONS USING 16-GA. STEEL

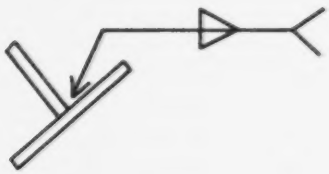
Equipment:

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
16-ga. steel, as selected by instructor
Safety glasses

Specifications:

Joint design and weld symbol





Filler metal and number of beads:
E6010 or 6011, 1/16", 3/32" or 1/8" single pass
E6018, 3/32" or 1/8" single pass
Positions: flat (1F), horizontal (2F), vertical (3F), overhead (4F)
Cleaning: chip and wire brush
Testing: visual
Technique: downhand welding to prevent burn-through; drag (1F-3F) and very slight whip (4F)

Procedure:		Evaluation 3	2	1	N
1.	Attach ground clamp to table or workpiece. Select correct polarity for electrode.	—	—	—	—
2.	Turn on welding machine. Adjust to correct amperage by running a short bead on scrap metal.	—	—	—	—
3.	Prepare plates as required to form the joint. Tack both ends of the joint.	—	—	—	—
4.	Place the joint so the weld will be in the correct position. Place electrode in holder.	—	—	—	—
5.	Strike arc and adjust electrode to correct arc length. Adjust travel speed and electrode arc as required to make correct bead shape.	—	—	—	—
6.	Weld the entire length of the joint and quickly backfill at edge of joint.	—	—	—	—
7.	Secure workpiece with pliers. Chip and brush weld.	—	—	—	—

8. Inspect weld visually for undercutting, burn-through, and uniform bead. — — — —

9. Ask instructor to check your work. — — — —

10. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competencies H1-H8.

MAKE SQUARE BUTT WELDS IN VARIOUS POSITIONS USING 16-GA. STEEL

Equipment:

SMAW machine with accessories
Personal safety clothing and equipment
Pliers
Chipping hammer and wire brush
16-ga. steel, as selected by the instructor
Safety glasses

Specifications:

Joint design and weld symbol

Filler metal and number of beads:
E6010 or 6011, 1/16", 3/32" or 1/8" single pass
E6018, 3/32" or 1/8" single pass
Position: 1 plate E6010 (flat 1G)
1 plate E6018 (horizontal 2G, vertical 3G, overhead 4G)
Cleaning: chip and wire brush
Testing: visual
Technique: downhand welding to prevent burn-through; drag for all positions. Use slight whipping motion in overhead position if insufficient penetration occurs

Procedure:		Evaluation 3 2 1 N
1.	Attach ground clamp to table or workpiece. Select correct polarity for electrode.	— — — —
2.	Turn on welding machine. Adjust to correct amperage by running short bead on scrap metal.	— — — —
3.	Prepare plates as required to form the joint. Tack both ends of the joint.	— — — —
4.	Place the joint so the weld will be in the correct position. Place electrode in holder.	— — — —
5.	Strike arc and adjust electrode to correct arc length. Adjust travel speed and electrode angle as required to make correct bead shape.	— — — —
6.	Weld the entire length of the joint and backfill at edge of joint.	— — — —
7.	Secure workpiece with pliers. Chip and brush weld.	— — — —
8.	Inspect weld visually for undercutting, burn-through and uniform bead.	— — — —

9. Ask instructor to check your work. _ _ _ _

10. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. _ _ _ _

Average of above evaluations* _ _ _ _

*This average is the student's final evaluation for competencies H9-H16.